THE COLLEGIAN STANDARD BOOKS SERIES

EXAMPLES IN PHYSICS

AND

UNIVERSITY PAPERS

WITH ANSWERS.

EXAMPLES IN PHYSICS

AND

UNIVERSITY PAPERS

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ANSWERS.

(*For the Students of the Intermediate Course*).

SECOND EDITION

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PREFACE.

FIRST EDITION

The book has been written to remove the long-felt want of a suitable book of Examples in Physics for the students of our Intermediate Course As the books already existing in the field have not evidently been written with a view to the special requirements of our students, we bring out this publication compiled by authors of long experience

In the preparation of the book care has been taken to select examples which are at once instructive, typical and important, judged from the nature of the problems set in the University Papers A special feature of the book is that problems of every possible variety have been given either a complete solution or direct hints to that effect to guide the students

Further, explanatory notes have been inserted by way of helping the memory of a student in the proof of an important formula which he has culled from the text books

To make the publication the more useful, we have inserted the University Intermediate Questions in Physics with their Answers The latter has been arranged in a way as not to render full help to the student but just to give him sufficient scope in exercising his own intelligence in trying to find the full answers For the covenience of the students the subject-

matter of each question has been shown in the margin, morever, in cases where a question has been repeated, the the year, the paper and the question number of such repititions have also been put in the margin, from which the student will be able to realise for himself the importance of a question

In conclusion, it may be confidently said that a student, going through the book, will be able to save much of his time and trouble and will be fully competent to answer problems of any type set in the University examinations

January 1, 1916,
CALCUTTA

THE PUBLISHERS

SECOND EDITION.

We are glad to note that the book has been given a warm reception by those for whom it is written The opportunity of a fresh edition has been utilized in printing the part I of this book in bolder types and in making some useful additions and alterations The *Contents* and the *Index* have been much fuller than before

December 1, 1919,
CALCUTTA

THE PUBLISHERS

EXAMPLES IN PHYSICS.

CHAPTER I.

Pendulum —

The formula that holds in the case of a simple pendulum is

$$t=2\pi\sqrt{\frac{l}{g}}$$

where t = time of a complete oscillation in seconds
l = length of the pendulum
and g = acceleration due to gravity

A *Seconds* pendulum is one which makes *half* a complete oscillation in a second

$$i\ e \quad 1=\pi\sqrt{\frac{l}{g}}$$

EXAMPLES —

1 The value of g at a place is 981 cm per sec per sec Find the length of the seconds pendulum [C U 1912,'17,'19

Let l = required length of pendulum,

then $$1=\pi\sqrt{\frac{l}{g}}=\pi\sqrt{\frac{l}{981}}$$

$$1=\pi^2\frac{l}{981}$$

$$\therefore l=\frac{981}{\pi^2}=\frac{981}{9\ 87}=99\ 39\ cm.$$

2 Show that in a place where $g=987$, a pendulum would beat seconds if its length were 1 metre

32 2, what is the length of a pendulum vibrating s? [Ans —5 1 ft

dulum is 7 feet in length and it makes 10 complete ons in 20 seconds Find the value of g at the [Ans —69 1 ft per sec

he value of g at the top of a mountain where a nstructed to beat seconds at a place where be shortened $\frac{3}{15}$ ths of its original length in it beat seconds [Ans —150

Hints — $1=\pi\sqrt{\dfrac{l}{950}}=\pi\sqrt{\dfrac{l\frac{12}{15}}{g}}$

ngth of a seconds pendulum is 39 2 in, find the pendulums which will vibrate in $\frac{1}{4}$ sec and [Ans —2 45 in, 156 8 in

e length of a pendulum which will oscillate 56 onds [Ans —37 5 in

ints — $t=55/56=\pi\sqrt{l/g}=\pi\sqrt{l/32}$

iny oscillations will a pendulum of length 4ft ? [Ans —24685 approx

nts — $t=\pi\sqrt{l/g}=\pi\sqrt{4/32\ 2}$

The number of oscillations in a day (86400 given by $n=\dfrac{86400}{t}$

econds pendulum loses 9 seconds per day, alteration in its length, so that it may keep

5400 seconds

dulum loses 9 seconds per day, it beats y or 86391 times in 86400 seconds, so that ion is 86400/86391 second (and not 1 second

s length Now

$$\pi\sqrt{\frac{l}{g}}=\frac{86400}{86398} \quad (1)$$

Let its length be changed from l to $l+x$ to make it keep correct time, since, in that case, it becomes a true seconds pendulum, its time of oscillation becomes 1 second

$$\text{Hence} \qquad \pi\sqrt{\frac{l+x}{g}}=1 \qquad (2)$$

$$\text{From (1) and (2)} \quad \pi^2\frac{l}{g}=\left(\frac{86400}{86391}\right)^2 \quad \text{and} \quad \pi^2\frac{l+x}{g}=1$$

$$\text{Subtracting} \quad \pi^2\frac{x}{g}=1-\left(\frac{86400}{86391}\right)^2$$

$$=1-\left\{1+\frac{9}{86391}\right\}^2$$

$$=1-\left\{1+\frac{18}{86391}+\text{etc}\right\}$$

$$=-\frac{18}{86391}$$

$$x=\frac{g}{\pi^2}\times\left(-\frac{18}{86391}\right)=-\frac{32\times 7^2}{22^2}\times\frac{18}{86391}$$

Hence the length of the pendulum must be *shortened* by 008 in

10 A faulty seconds pendulum loses 20 secs per day Find the alteration in its length so that it may keep correct time [*Ans* — 015 in

11 Two simple pendulums of length 1 metre and 1 1 metre respectively start swinging together with same amplitude Find the number of swings that will be executed by the longer pendulum before they are again swinging together [$g=978$ cms/sec] [C U 1909 *Ans* – 5

12 If the frequency of oscillation of a pendulum is 98 per minute at a place where $g=980$ cm per second per second, find the length of the pendulum [C U '16 *Ans* —9 3 *cm*

CHAPTER II.

HYDROSTATICS

es, the following facts may be noted —

ı cubic foot of water is 1000 ounces or ls

a cylinder of radius r is πr^2

ace of a sphere of radius r is $4\pi r^2$

a sphere is $\frac{4}{3}\pi r^3$

Density

any body is given by the formula

$\frac{M}{V}$ where

M = mass of the body,
V = volume " "

ns in radius has a mass of 10 kilograms

$\frac{4}{3}\pi r^3 = \frac{10 \times 1000}{\frac{4}{3} \times \frac{22}{7} \times 8000} = 0\ 29$ *gms per c c*

tal weighs 40 5 kilograms and its volume s density? [*Ans*—2 7 gms/c c

ity of a substance which is five times as your answer in ounces per cubic in [*Ans*—2 89 oz per cub in

by 4 by 10 5 cm What weight of water [*Ans*—336 *gms*

ight of a litre of mercury (Density of c [*Ans*—13600 gms

6 A capillary glass tube weighs 2 gm A thread of mercury 10 cms long is drawn into the tube when it is found to weigh 6 gm Find the diameter of the capillary tube

Hints,—Wt of mercury $= \pi r^2 \times 10 \times 13\ 6 = (6 - 2)$gm

Hence $r = 03$ cm

7 The mass of 10 cub ft of a metal is 800 lbs Find its density in gms per c c

1 lb $= 453\ 6$ gms and 1 cub ft $= 28315$ *c c*

$$\text{Hence } \rho = M/V = \frac{800 \times 453\ 6}{10 \times 28315} = 1\ 28 \text{ gms per } c\,c$$

8 Iron has a density of 7 76 Find the weight of 100 cub ft of iron [*Ans*—48361 *lb*

9 Density of glass is 2 5 Find what volume weighs 4 25 gms [*Ans*—1 7 *c c*

10 A body weighs 500 lbs and its density is 4 Find its volume? [*Ans*—2 *cub ft*

11 A flask when empty weighs 120 gms When full of air it weighs 121 3 gms and when full of water 1220 gms calculate the density of air [*Ans*—0 00118

Fluid Pressure —

The *intensity* of pressure at a point A *i e* the pressure per unit area round A at a depth h below the surface of a liquid of density ρ (neglecting the atmospheric pressure) is given by the expression $p = g\rho h$

If the atmospheric pressure is taken into account, the pressure at A is given by

$$p = g\rho h + \pi$$

where π is the atmospheric pressure on unit area of the surface of the liquid

EXAMPLES —

12 Find the pressure due to a column of mercury 50 cms high Does the pressure vary with the diameter of the tube in which the mercury is made to stand?

ρh

$\cdot 81 \times 13\ 6 \times 50$, taking $g = 981$

$\cdot 667 \times 10^6$ *dynes*

$\cdot 667$ *megadynes*

end and closed at the other,
density 13 6) The closed end
ir, and the mercury in the open
than it does in the closed limb
nsity of pressure on the air in
U 1910 *Ans*—1 4 × 10[6] dynes

essure and intensity of pressure

eight of a column of water in
se may be equal to 10[6] dynes
[*Ans*—1019 4 *cms*

er is 1 025 Find the pressure
surface in pounds per sq ft

an area of 1 sq ft = 10 cub ft

weighs—62 5 lbs

r „ —62 5 × 1 025 = 64 06 lbs

sea-water weighs—10 × 64 06 =

d this is the pressure per sq ft

sq cms is sunk to a depth of
f a liquid of density 0 55 Find
[*Ans*—22 gms wt

d from a tank at a height of
water pressure?
[*Ans*—2604 lbs per sq in

the bottom of a pond 15ft
re being 15 lbs per sq inch
[*Ans*—21 5 lbs

circular disc 16 cms in diam
6) in order that the pressure
[*Ans*—25 cms

hich is 10 cms is suspended
and its upper surface at a depth

of 10 cms below the surface Find the pressure on each of its faces [*Ans* —100 gms above, 2000 gms below and 1500 gms on the sides,

Archimedes' Principle —

A body immersed in a liquid seems to lose a part of its weight due to an upward pressure exerted by the liquid, and this apparent loss in weight is equal to the weight of the displaced liquid, the volume of which is necessarily the same as that of the body immersed

EXAMPLES —

22 Describe how you would demonstrate experimentally the truth of the principle of Archimedes and explain what is meant by the apparent weight of a body in water

23 Explain how Archimedes' Principle may be used to distinguish a metal from its alloy [C U, 1912

24 State the condition of floatation of a body immersed in a liquid

25 What volume of water will be displaced by a block of wood of 590 gms weight The specific gravity of wood is 0 65 [*Ans*—500 c c

26 A piece of cork of mass 100 gms and density 0 25 floats in a vessel full of water Find how much water overflows [*Ans* —100 c c

27 A plate 10 metres square is placed horizontally 1 metre below the surface of water, when the height of the mercury, in barometer is 760 millimetres What will be the total pressure on the plate? (The density of mercury = 13 6) [C U '11, *Ans*—1133 $6 \times 981 \times 10^6$ dynes

28 A lump of copper weighing 16 ozs is placed in a tumbler and causes 1 8 ozs of water to overflow Calculate the specific gravity of copper [*Ans* —8 88

29 The specific gravity of sea-water is 1 028 and that of ice is 0 918. What fraction of the volume of an ice-berg floats out of water?

... of the ice-berg
... outside the water
... of floatation,
... d pressure of the displaced

$- V^1) \times 1\ 028$

$\frac{918}{8} = 107$

...nly 500 cubic yards exposed
...ific gravity of ice is 0 918 and
[*Ans*—4423 *cub yds*

...ing 20 gms floats in water
...d Find the density and the
...2 gms per c c , vol—100 c c

...ific gravity 0 5 is floating in
...nd the fraction of its volume
[*Ans*— 06

33 A block of wood 10 lbs wt floats in a liquid with ⅓rd of its volume above the surface What weight must be placed on the block in order just to sink it? [*Ans*—5 lbs

34 Determine the position of equilibrium of a sphere of glass (density 2 8) which is dropped into a vessel containing mercury and water (Density of mercury is 13 6)

Let V be the volume of the sphere and V' the portion of its volume immersed in mercury

Then $(V-V')$ of the volume of the sphere is in water

$V \times 2\ 8 = V' \times 13\ 6 + (V - V') \times 1$

Or $V \times 1\ 8 = V' \times 12\ 6$

Hence $V'/V = 143$ or the sphere will rest in equilibrium with only 143 part of its volume immersed in mercury

Atmospheric Pressure—

If π denotes the atmospheric pressure in dynes per sq. cm, then $\pi = h\rho g$

where h is the barometric height
ρ ,, ,, density of mercury (= 13 596)
g ,, ,, acceleration due to gravity

The normal atmospheric pressure *i e* that due to the barometric height of 76 cms is given by

$$\pi = 76 \times 13\ 596 \times 981 = 1{,}013{,}663 \text{ dynes}$$

In order to express the atmospheric pressure in gms weight per sq cm —we consider 1 barometric pressure due to a column of mercury 76 cms high and 1 sq cm cross-section—this quantity of mercury occupies 76 *c c*

Now, 1 *c c* of water weighs 1 gm
76 ,, ,, 76 gms

Hence ,, ,, mercury ,, $76 \times 13\ 596$ gms = 1033 gms

Thus the press is equal to a wt of 1033 gms per sq cm

Again to express the atmospheric pressure in pounds per sq inch,—we consider a barometric column 30 inches high and 1 sq cm cross-section, this column occupies a volume of 30 cub inches

Now 1 cub ft of water weighs 62 5 lbs.

1 cub inch ,, ,, $\frac{62\ 5}{1728}$ lbs

and ,, ,, mercury ,, $\frac{62\ 5}{1728} \times 13\ 596$ lbs

30 ,, ,, ,, ,, $\frac{62\ 5}{1728} \times 13\ 596 \times 30$

$= 14.75$ lbs

Hence, the atmospheric pressure is equal to a weight of 14 75 lbs per sq inch

EXAMPLES —

35 Deduce the pressure per sq cm. corresponding to a barometric height of 70 cms

of mercury in a column 70 cms high and 1 sq cm area $= 70 \times 1$ c c

ht of 1 c c of water $= 1$ gm

of 1 c c of mercury $= 13\ 6$ gms

of 70 c c of mercury $= 70 \times 13\ 6$ gms

$= 9520$ gms

ure required $=$ wt of 9520 gms of mercury per sq cm

e thus ,—$p = \rho g h$

$= 981 \times 13\ 6 \times 70$ dynes per sq cm

ht of water-barometer is 30 ft Deduce the spheric pressure in ounces per square foot [*Ans* —30,000 oz/sq ft

the height of a water barometer when the r reads 20 inches ? [*Ans*—31 ft

of glycerine is 1 27 Find the height of a glywhen the water-barometer stands at 25 4 ft [*Ans*—20 ft

inge in the atmospheric pressure on a square by a fall of 1 inch in the height of the barometric column ? [*Ans*—0 4912/sq in

---

Boyle's Law —

The volume of a gas varies inversely as its pressure, temperature remaining constant

Let $V =$ initial vol of a gas

$P =$ its initial pressure

and $V' =$ its altered volume

$P' =$ corresponding pressure

Then $PV =$ a constant, by this law

$= P'V'$

EXAMPLES —

40 State Boyle's Law, and explain it ? What is the relation between the density and pressure of a gas ?

41 The volume of a quantity of gas is measured when the barometer stands at 70 cms and is found to be 760 cc What will be its volume at the normal pressure ?

Normal pressure = weight of 76 cms height of mercury

Now apply Boyle's Law $PV=P'V'$

Here $P=76$, $P'=70$ and $V'=760$

we have $V=\dfrac{70\times 760}{76}=700$ c c

42 Find the pressure at which the gas in the preceeding question will occupy a volume of 532 c c [*Ans*—100 7 cms

43 At a pressure of 78 cms a quantity of hydrogen measures 100 cc Find the pressure when the volume is increased to 150 cc [*Ans*—52 cm

44 If a certain pressure is equal to that exerted by a column of mercury of height 760 mm, find its magnitude Density of mercury = 13 6 [C U 17, *Ans*—1033 6×981 dynes

45 At 76 cms pressure one litre of air weighs 13 gms What will be the weight of air contained in a litre flask when the barometer reads 80 cms ?

At 76 cms pressure 1 litre at 80 occupies a volume

$=\frac{80}{76}$ litres (from Boyle's Law)

Its weight $=\frac{80}{76}\times 1\ 3=1\ 37$ gms approx

46 A uniform tube closed at the top, open at bottom is plunged into mercury, so that it contains 25 cc of gas at an atmospheric pressure of 76 cms, the tube is now raised until the gas occupies 50 cc How much has it been raised ?

[*Ans*—63 cms

47 The volume of an air-bubble increases six-fold in rising from the bottom of a lake Find the depth of the lake, —the barometer reading 70 cms (Density of mercury = 13 6)

Pressure at the bottom of the lake—

= atmos press + press due to h depth of water
= wt of $70\times 13\ 6$ cm of water + wt of h cm of water
= wt of ($70\times 13\ 6+h$)cm. of water

From Boyle's Law

$$(70\times 13\ 6+h)\ V=70\times 13\ 6\times 6V$$

whence $h=47\ 7$ metres

ır-bubble at the bottom of a pond 15 ft deep has ıl to 1/1000 of a cubic inch, find its volume ies the surface, the height of water-barometer [*Ans*—0 0015 cub in.

ıantity of air 3 cc in vol and at atmospheric troduced into the space above a barometric originally stands at 760 *mm* The column is 190 *mm* Find the volume occupied by the [*Ans* —4 c c

-Apply Boyle's Law

$_1 P_1 = V_2 P_2$ {*i e* $3 \times 760 = V_2(760 - 190)$}

rometer tube of uniform bore is 34 in long A of air is left in the tube above the mercury, so eter registers 30 in when the true atmospheric 05 in What will be the true barometeric reading neter registers 28 in ?

—volume V_1 of enclosed air is $(34 - 30) = 4$ units

ıt a pressure $P_1 = (30\ 05 - 30) = \ 05$

y, the volume is $(34 - 28) = 6$ units

ıt a pressure $= P_2$ (say,)

$$V_1 P_1 = V_2 P_2$$

Or $4 \times 05 = 6P_2$ whence $P_2 = 03$

is is the pressure of air enclosed

ometric pressure $= 28 + 03 = 28\ 03$ in

y barometer contains some air which occupies ıds at 740 *mm* when a true barometer indicates 0 *mm* find the volume the air will occupy at ssure 760 mm [C U 1911 *Ans*—0 132 c c

of air weighs 1 293 grammes at a pressure of 0 o°C What will be the weight of a litre of e temperature when the barometer stands at [C U 15, *Ans*—1 327 gms

n quantity of gas is allowed to expand to 1 5 l volume What will be the pressure it will originally at a pressure of 750 millimetres temperature remaining constant throughout? [C U 1916, *Ans*—500 *mm*

Specific Gravity —

$$\text{Sp Gr} = \frac{\text{wt of a body}}{\text{wt of eq vol of water}}$$

EXAMPLES —

54 Distinguish between density and specific gravity of a body

Express the specific gravity of lead both in the $C\,G\,S$ and $F\,P\,S$ systems

55 A ton of metal occupies a volume of 10 cub ft Find its specific gravity referred to water as the standard substance?

$$1 \text{ ton} = 2240 \text{ lbs}$$

The mass of a cub ft of the metal is, $(2240 - 10)$ lbs and the mass of a cub ft of water is 62 5 lbs

Hence the required specific gravity (which is the ratio between the masses of equal volumes) is

$$224 \div 125/2 = 448/125 = 3\ 58,$$

56 A cylindrical glass tube has a length of 21 cms and its internal diameter is 0 8 cm Find how many grammes of mercury will be required to fill the tube

Mass of mercury in the tube

$$= V\rho = \sigma l\rho \text{ where } \sigma = \text{cross-section of the tube}$$

$$= \tfrac{22}{7} \times 0\ 16 \times 13\ 6 = 143\ 6 \text{ gms}$$

57 The internal diameter of a cylinder is 2 cms its length is 2 metres and its weight when empty is 175 gms, when filled with a liquid it weighs 285 gms Find the specific gravity of the liquid [*Ans*—0 31

58 Two litres of a liquid of specific gravity 0 5 is mixed with one litre of another liquid of specific gravity 1 5 and the mixture occupies half the volume of its components Find the specific gravity of the liquid?

The volume of the mixture is $\frac{1}{2} \times 3000 = 1500$ c c

If ρ is the density, the mass of the mixture in gms is

$$V = 1500 \times \rho \text{ gms}$$

$$500 \times \rho = (1000 \times 1\ 5) + (2000 \times 0\ 5)$$
$$= 1500 + 1000 = 2500 \text{ cc}$$
$$\rho = 2500/1500 \quad = 1\ 6$$

of metal of specific gravity 8 9 weighs 15 8
Find its volume [C U '14 , *Ans*—2 c c

of metal weighs 100 grammes in air and 88
r What would it weigh in a liquid of specific
[C U '15 *Ans*—82 gms

veights of two liquids of specific gravity 0 2
d together and a contraction of 5 per cent
olume What is the specific gravity of the
[*Ans*—2 5

ire is made of 7 c c of a liquid (specific
l 3 c c of water The specific gravity of the
d to be 1 615, Determine the amount of
[*Ans*—0 3 c c

cific gravities of two liquids be 2 and 3 res-
e specific gravity of a mixture containing 7
of the former to 3 parts by volume of the

Mass of 1st $= (7 \times 2) = 14$
" " 2nd $= (3 \times 3) = 9$
Total mass $= 23$ and total vol $= 10$
Hence $\rho = 23/10 = 2\ 3$

volumes of three liquids are mixed together
pecific gravity 2, that of the second is 3 and
ty of the mixture is 2 6 Find the specific
rd [*Ans*—2 8

uids have specific gravities 2 and 3 respect-
weight of the former is mixed with 3 parts
e latter Find the specific gravity of the
[*Ans*—2 2

weighs 20 gms in vacuo and 15 gms in water
and specific gravity

= weight of displaced water
(by Archimedes' Principle)
$= (20 - 15)$ gms $= 5$ gms

Vol of body $= 5$ c c

Specific gravity $= 20/5 = 4$

67 Find the apparent weight of a substance (density $= 2$) in water which weighs 10 gms in vacuo [*Ans*—5 gms.

68. A body weighs 62 gms in vacuo and 42 gms in water, find its volume and specific gravity

[C U '19, *Ans*—vol 20 c c, sp gr 3 18.

69 Find the volume of a solid which weighs 100 gms in vacuo and 50 gms in water [*Ans*—50 c c

70 A hollow metal stopper weighs 30 gms in air and in water it weighs only 5 gms The density of the metal being 3, find the volume of the internal cavity

Here, volume occupied by the metal (excluding the cavity)

$= \frac{30}{3} = 10$ cc $=$ vol of displaced water

$=$ loss of wt of body in water

Now, total volume $= (30 - 5) = 25$ c c

Hence volume of cavity $= 15$ cc

71 Weight of a body in air is 20 gms and in water it weighs 15 gms Find its apparent weight in a liquid of specific gravity 0 5 [*Ans*—17 5 gms

72 Two bodies are in equilibrium when suspended in water from the arms of a balance the mass of one is m_1 and its density is s_1. If the mass of the other is m_2 what is its density?

Volume of the 1st body $v_1 = m_1/s_1$

" " 2nd " $v_2 = m_2/s_2$ where,

$s_2 =$ its density

App wt of the 1st body in water $= m_1 - m_1/s_1$

" " " 2nd " " $= m_2 - m_2/s_2$

and these are equal, being in equilibrium,

Hence, $m_1 - m_1/s_1 = m_2 - m_2/s_2$ whence s_2 is found

73 Two masses of 28 gms and 36 gms respectively balance each other when weighed in water The specific gravity of the first is 5 6 Find the specific gravity of the other [*Ans*—2 77

74 Two masses *A* and *B* are suspended from the two arms of a balance and are in equilibrium when *B* is immersed

795) and A in Nitric acid (specific
c gravities of A and B are 19 3 and
e the masses of the two
[*Ans*—Mass of B is 997 times A's

weighs 100 gms in air, 70 gms in
ier liquid Find the specific gravity

water = 100 − 70 = 33 gms
= weight of watter displaced in c c

l = 100 − 58 = 42 gms
= weight of liquid displaced

f the liquid
= 42/30 = 1 4

ity of a metal is 19, what will be the
f the substance ?
[C U '17 , *Ans*—360 gms

o gms in vacuo and 60 gms in a
5 Find the specific gravity of the
[*Ans*—3

o gms in air, 84 gms in water and
Find the specific gravity of the
[*Ans*—1 625

of wood of specific gravity of 0 7
pletely immersed, when a body of
on it Find the weight of this body,
of wood is 100 c c
[C U '13 , *Ans*—36 gms

gravity of a given solid which is
following data —

of solid in air = 0 2 gms
f sinker in air = 3 0 gms

sinker) in water = 2 45 gms
vity of sinker = 7 0

to sinker alone = 3 0/7 = 0 43 gms
, 2 − 2 45) gms = 0 75 gms
olid = 0 75 − 0 43 = 0 32 gms

=weight of an equal volume of water

∴ Specific gravity of the solid=0·2/0·32=·625

81. Find the specific gravity of a piece of wood from the following data :—weight of wood=230 gms., weight of a piece of iron in water=580 gm., weight of the wood and iron together in water=465 gms. [*Ans.*—0·6

82. A piece of cork weighing 10 gms. and a sinker weighing 38 gms. just sink together when placed in water. The specific gravity of the sinker being 4·75, find that of the other. [*Ans.*—0·25

83. A Nicholson hydrometer required a weight of 8·35 gms. to be placed on the upper pan in order to make it sink to a fixed mark on the stem. The weights taken off when a piece of metal was placed in the upper pan were 5·81 gms. ; the weights added when the piece of metal was transferred to the lower pan were 2·92 gms. Find the specific gravity of the metal.

The weight of the metal is evidently=5·81 gms.

Again the buoyancy of the metal is 2·92 gms.

Hence specific gravity $=\frac{5\cdot81}{2\cdot92}=1\cdot99$

84. A Nicholson hydrometer sinks to a certain mark in a liquid of specific gravity 0·6, but it takes 120 grammes to sink to the same mark in water. What is the weight of the hydrometer? [C. U. '18. *Ans.*—180 gms.

85. In an experiment with a solution of salt in water containing 30 gms. of salt in 100 gms. of the solution the weight of the hydrometer was 10 gms. and the weight required to make it sink in water was 15 gms. The weight required to sink it in the salt solution was 17 gms. Find the specific gravity of the salt solution.

Here, weight of water displaced

=weight of the hydrometer
+weight on the hydrometer pan
=(10+15) gms.=25 gms.

Weight of salt solution displaced
=27 gms.

nce, specific gravity of salt solution

$$=\frac{27}{25}=1\ 08$$

Nicholson's hydrometer weighs 200 grammes and grammes in the upper pan to sink it to the fixed weight must be added to or subtracted from the he upper pan to bring it to the fixed mark, when in a liquid of specific gravity 1 2 ?

[C U '11, *Ans*—50 gms

o gms has to be placed in the pan of a hydrometer the mark in water and 50 gms only in another the weight of the hydrometer is 100 gms, find the vity of the liquid ? [*Ans*—0 75

flask which when filled with water weighs altogether as 80 gms of a solid introduced, and being then th water weighs 470 gms What is the volume of ne of the solid and also the specific gravity of the

[*Ans*—volume 2 50 cc , sp gr—4

nugget of gold mixed with quartz weighs 12 ounces pecific gravity 6 4 , given that the specific gravity 19 35 and of quartz 2 15 Find (to one place of ie quantity of gold in the nugget

Let x be the quantity of gold in the nugget
Then $12-x$ is „ quartz „

$$\text{Then vol of gold}=\frac{x}{19\ 35},$$

$$\text{and} \quad „ \quad \text{quartz}=\frac{12-x}{2\ 15}$$

l contained in the nugget $=x/19\ 35+(12-x)/2\ 5$

$$\text{is}\left(\frac{x}{19\ 35}+\frac{12-x}{2\ 15}\right)6\ 4=12 \text{ ozs}$$

$$x=8\ 9 \text{ ozs}$$

lump of metal is known to consist of silver and is not known how much gold and how much silver weighs 20 gms in air and 18 7 gms in water How is there in the mixture ? Specific gravity of gold silver = 10 5 [*Ans*—13 92 gms

91 A piece of lead weighs 7 88 gms in air, 7 19 gms in water and 7 33 gms in alcohol A piece of oak weighs 13 21 gms in air and the oak and lead together weigh 4 87 gms in water, find the specific gravity of lead, oak and alcohol

[*Ans*—lead-11 42, oak-0 85, alcohol 0 797

92 A body of specific gravity 1 85 is weighed in a mixture of alcohol, (specific gravity 0 82) and water Its weight in air is 28 8 gms and in the mixture -14 1 gms Find the proportion of alcohol present?

Weight of water displaced $=28\ 8/1\ 85 = 15\ 57$ gms
Weight of mixture displaced $=28\ 8-14\ 1 = 14\ 7$ gms
Specific gravity of mixture $=14\ 7/15\ 57 = \ 944$

Now, Let V=total volume of mixture
V^1=volume of alcohol present
Then $V-V^1$=volume of water present
Hence $V\times\ 944=(V-V^1)\times 1+V^1\times\ 82$
Or $V\times\ 056=V^1\times\ 18 \qquad V^1=\ 31\ V$
0 31 of the volume is alcohol

93 The volume of a balloon is 200 cubic metres and its weight with car is 120 kilograms Determine the lifting power of the balloon when it is filled with coal gas 1 litre of which weighs 1 193 gm, a litre of air weighing 1.293 gm

Buoyancy per litre $=1$ 1
Volume of balloon $=200\times 100\times 100\times 100$ cc
" $=200\times 10\times 100$ in litres
Buoyancy $=200\times 1000\times 1\ 1=220{,}000$
Lifting Power $=220{,}000-120{,}000=100{,}000=100$ kgm

94 A prism of cork, 16 cms high, and of square section equal to 2 cms side is cemented to a prism of lead of the same cross-section and 1 cm high The composite prism is allowed to float in water How much of it will project above the surface of the water? [Specific gravity of cork -0 25 specific gravity of lead -11] [C U '10, *Ans*—2 cms

95 1 litre of hydrogen and a litre of air weigh about 0 9 gramme aud 1 3 grammes respectively at a certain temperature *(t)* and pressure *(p)* What will be the capacity of a balloon weighing 10 kilogrammes, which just floats when filled with hydrogen having the same pressure *(p)* and the same temperature *(t)* as the air? [C U '12, *Ans*—8264 46 litres.

96 Find the lifting power of a balloon of 500 cubic metres capacity and filled with hydrogen (1 Litre of hydrogen weighs 0 089 gm that of air -1 293 gm) [*Ans* —60 2 kg

97 Describe some form of air-pump If the size of the receiver of an air-pump be 1 cub ft and that of the barrel of the pump 24 cub in , how many strokes are required to reduce the pressure of the air to one-tenth the atmospheric pressure ?

Let V = vol of receiver = $12 \times 12 \times 12$ cub in
v = vol of barrel = 24 cub in
ρ = density of air before the operation
ρ_1 = „ „ after 1st upstroke
ρn = „ „ „ nth „

Then after the 1st upstroke

$$V\rho = (V+v)\rho_1 \text{ whence } \rho_1 = \frac{V}{V+v}\rho$$

After the nth upstroke $\rho n = \left(\frac{V}{V+v}\right)^n \rho$

By Boyle's law, density varies as pressure
Hence $\rho n/\rho = 1/10$,

Substituting for V and v, $\left[\frac{72}{73}\right]^n = \frac{1}{10}$

Or $n\{\log 72 - \log 73\} = -\log 10 = -1$
Or $n\{1\ 857 - 1\ 863\} = -n(\ 006) = -1 \quad n = 167$

98 The volume of the receiver of an air pump is 500 cc and that of the barrel is 75 cc Find after how many strokes the press is reduced to less than half of its original vol [*Ans* —5

99 Explain how to compare the densities of two liquids which do not mix by means of a U-tube Mercury is placed at the bottom of such a tube and water sufficient to occupy a length of 54 cms of the tude is poured into one limb By how much will the level of mercury be altered and how much oil must be poured into the other limb to bring it back to its original position ? [*Ans* —rises 1 99 cms , falls 1 99 cms

100 The lower portion of a U-tube contains mercury How many inches of water must be poured into one limb of the tube to raise the mercury 1 inch in the other [*Ans* —27 2 in

CHAPTER III.

HEAT.

Thermometric Scales —

The rule of conversion from one scale to another is given by

$$\frac{F-32}{9}=\frac{C}{5}=\frac{R}{4}$$

EXAMPLES —

1 Find the relation between the different scales of temperature

2 Convert the following centigrade temperatures into their equivalent Fahrenheit

(i) 20°C (ii) 850°C (iii) − 6°C (iv) − 50°C (v) 180°C
[*Ans* —68° 1562° 21°2 ; 58° , 12°F

3 Convert the following into their equivalent Centigrades

(i) 230°F (ii) 27°F (iii) -10°F (iv) -49°F
(v) 212°F (vi) 32°F
[*Ans* —110° , 2 9° , -23°3 450° 100° , 0°

4 The freezing point of mercury is given by the same numbers on the Centigrade and Fahrenheit scales Find the temp

We have $\frac{F-32}{9}=\frac{C}{5}$

Let x be the reqd reading on both the thermometric scales

then $\frac{x-32}{9}=\frac{x}{5}$ or $x=\frac{9}{5}x+32$ $x=-40$

5 Convert the following Centigrade temperatures to their equivalent Fahrenheit and represent their relation by a graph

(1) 10°c (2) 20°c (3) 30°c (4) 40°c (5) 50°c (6) 60°c
(6) 60°c (7) 70°c (8) 80°c (9) 90°c (10) 100°c

6 Find the temp which is given by the same reading on both the Fahrenheit and the Reaumer scales [*Ans* —25°

Expansion of Solids —

Let l_0 be the length of a body at 0°C
l_1 „ „ „ „ at t° C
α the linear co efficient of expansion of the substance of the body

Then $$\alpha = \frac{l_1 - l_0}{l_0 t} \quad (1)$$

Hence $$l_1 = l_0(1 + \alpha t) \quad (2)$$

And increase in length $= l_1 - l_0 = l_0 \alpha t$ (3)

Similarly for surface and volume expansions we have

Surface expansion $S = S_0 (1 + \beta t)$

Volume „ $V = V_0 (1 + \gamma t)$

where β = the co eff of superficial expansion $= 2\alpha$
and γ = „ „ cubical „ $= 3\alpha$

Again for expansion of a solid between any two tematures

we have $l = l_0 (1 + \alpha t)$

and $l' = l_0 (1 + \alpha t')$

$$\frac{l'}{l} = \frac{1 + \alpha t'}{1 + \alpha t}$$

or $$l' = l \, \frac{1 + \alpha t'}{1 + \alpha t}$$

i e $$= l(1 + \alpha t' - \alpha t + \ldots$$
$$= l(1 + \alpha t' - \alpha t)$$

neglecting terms involving square and other powers of α, as α itself is very small

Hence $l' = l \{1 + \alpha (t' - t)\}$

EXAMPLES —

7 The length of a copper rod at 0°C is 100 cms, Find its length at (1) 100°C (2) 150°C (3) 500°C,

$$l' = l_0 (1 + \alpha t)$$

Here $=100\ (1+\ 000017 \times 100)$
$=100 \times 1\ 0017 = 100\ 17$ cms

8 A bar of steel is 10 yds long at 0°C What will be its length at 30°C ? [*Ans* —10 00321 yds

9 The length of an iron rod at 0°C, is 100 cms Find its length at 10°C ? [*Ans* —100 012

10 If an iron steam-pipe is 60 ft. long at 0°C what is its length when steam passes through it at 100°C [*Ans* —60 072 ft

11 A piece of iron wire is exactly 100·24 cms at 200°C What will be its length at 0°C ?

$$l'=l_0\ (1+\alpha t)$$

Here $100\ 24 = l_0\ (1+\ 000012 \times 200)$

$=l_0 \times 1\ 0024 \qquad l_0 = 100$ cms

12 A brass and a steel rod are each one metre long at 10°C Find the difference in their length at 60°C [*Ans*—0 03 cms

13 A platinum wire and a brass wire each measures 300 cms at 100°C Find their length at 0°C
[*Ans*—Pt wire 299 4 cms , brasswire—299 5 cms

14 If a brass yard measure be correct at the temperature of melting ice what will be its error at the temperature of boiling water ?

Increase in length $= l_0 \alpha t = 36 \times\ 000019 \times 100 = 0\ 0684$

15 An iron bar 2 ft long at 0°C increases in length by a quarter of an inch, when placed in a furnace What is the temperature of the furnace ? [*Ans* —866 ·6C

16 The length of a certain copper rod is 30 in, at 0°C What is the length of a steel rod at 0°C that has the same length as the copper rod at 100°C ? [*Ans*—30 018 in

17 The iron rails on a railway are 5 ft long What space must be left between two consecutive rails to allow space for expansion if the temperature may range over 100°C ?
[*Ans* —0 072 in

18 The length of a glass tube at 0°C is 153 86 cms , at 100° it is 154 cms Find the co-efficient of expansion for glass
[*Ans* —6 0000086

19 A copper rod is 100 cms long at 0°C at what temperature will it have increased by 1 mm? [*Ans* —58 8C

20 Explain why the lengths of the metal bars of a compensated pendulum should be inversely proportional to the coefficient of expansion of the metals

21 A gridiron pendulum has 5 iron rods each of 1 metre length and 4 brass rods Find the length of each brass rod

As the expansion of rods of the same material on either side of the central rod are the same, we have to consider here the expansion of *three* iron rods and *two* brass rods only

$$\text{Hence } \frac{3l}{2l'} = \frac{0000189}{0000117} = \frac{189}{117}, \text{ whence to find } l'$$

22 A gridiron pendulum contains 3 feet of iron rod What length of zinc rod will be required to be used in its construction? [*Ans* —1 22 ft

23 The distance between two marks on a copper rod at 10°C is 200 34 in Find the length at 100°C

Here difference in temp $= 90°$

Increase in length $= l\alpha(t' - t)$

$= 200\ 34 \times 90 \times\ 000017 = 306$

length at 100°C $= 200\ 34 + 0\ 306 = 200\ 646$ in

24 What change takes place in the diameter of an iron hoop which measures 80 cms across at 10°C when the temperature changes to 30°C? [*Ans* —0 01952 cms

25 A certain bridge of iron is 30 yds long Find its change in length during the year, assuming the range of temp. to be -15°C to 45°C [*Ans* —0 2196 yds

26 Two bars of iron and copper differ in length by 10 cms at 0°C What must be the lengths of the rods in order that they may differ by the same amount at all temperatures? [*Ans* —Iron—30 cms, copper—20 cms

27 A certain clock with an iron pendulum rod is made to keep correct time at 5°C How will its rate alter if the temp rises to 30°C? [*Cf* Q 2 C U 1913

There are $24 \times 60 \times 60$ or 86400 secs in a day

A correct seconds pendulum will make 86,400 swings

Now the period of oscillation of a pendulum is given by

$$t=2\pi\sqrt{\frac{l}{g}}, \quad t'=2\pi\sqrt{\frac{l'}{g'}}$$

Here $\frac{t}{t'}=\sqrt{\frac{l}{l'}}=\sqrt{\frac{1}{1\ 0003}}$

For $l'=l_0(1+000012\times 25)$

$=l(1+0003)$

$=l\times 1\ 0003$

Here if $t=1$, $t'=\sqrt{1\ 0003}$

$$\text{No of swings at } 30^\circ\text{C}=\frac{86400}{\sqrt{1\ 0003}}$$

$=86400(1+0003)^{-\frac{1}{2}}$

$=86400(1-00015)$ approx

Hence the clock loses $86,400\times 00015$ secs

or 12 96 secs per day

28 1 A pendulum consists of a bob suspended by a steel wire whose co-efficient of expansion is $1\ 24\times 10^{-5}$ If the pendulum beats seconds at 0°C, find the number of seconds lost per day supposing that the temp is constant throughout the day and equal to 25°C [*Ans*—13 96 secs a day

29 An iron clock pendulum makes 86, 405 oscillations per day, at the end of the next day the clock has lost 10 seconds find the change in temperature

Times of oscillation in the two cases are

$$t=\frac{86400}{86405}\text{sec} \qquad \text{and } t'=\frac{86400}{86395}\text{sec}$$

Since the clock loses, its former length, say l, has evidently increased due to a rise of temperature t to some length l' such that

$$l'=l(1+0000117\ t)$$

But $\qquad t'/t=\sqrt{l'/l}$

$\sqrt{1 + 0000117t}$

$(1 + 000057t)^{\frac{1}{2}} = 1\ 00000585t +$

19° C

'n boiler is a circle of 3 ft in diameter
ge in its area when heared to 100°C?

cle $= \pi r^2 = \frac{22}{7} \times 1\ 5 \times 1\ 5$

$S_t = S_0\ (1 + t)$

$= \frac{22}{7} \times 1\ 5 \times 1\ 5(1 + 000024 \times 100)$

$= S_t - S_0 = \frac{22}{7} \times 1\ 5 \times 1\ 5 \times\ 0024$

$=\ 017$ sq ft

o cms long and 10 cms broad at 0°
100°C [*Ans* —100 38 sq cms

ι piece of glass at 100°C is 100 258
oo cms Find the co efft of cubical

$$V_t = V_0\,(1 + \gamma t)$$

$$100\ 258 = 100(1 + 100\gamma)$$

$$= 100 + 10000\gamma,$$

$$\gamma = \frac{258}{1000} = 0000258$$

33 Linear expansion for glass is 0 0000083 Find the volume at 15°C of a glass flask of exactly 1 litre capacity at 0°C [*Ans* —1000 37 c c

34 A glass vessel holds 6 litres at 15°C How much will it hold at 25°C? [*Ans*—6 0016 litres,

35 A lump of iron has a volume of 10 cub ft at 100°C Find its volume at 21°C (α for iron =000012)

$$V_t = V_0\{1 + \gamma(t' - t)\}$$

$$10 = V_0(1 + 000036 \times 75)$$

$$= V_0(1 + 0027)$$

$$V_0 = \frac{10}{1\ 0027} = 9\ 97 \text{ cub ft}$$

36 α for a certain metal is 0 000017 How much must be the temperature raised in order that it may increase 1 per cent in volume? [*Ans* —196° 1C

37 The density of a piece of glass at 10°C is 2 6001 and at 60°C is 2 5967 Find the mean co efficient of cubical expansion of glass

Now we have

$$\rho = \rho_0 (1 - \gamma t)$$

Here t the diff in temp is 50°C

$$2\ 5967 = 2\ 6001\ (1 - 50\gamma)$$
$$= 2\ 6001 - 50\gamma \times 2\ 6001$$

$$\text{Then } 50\gamma = \frac{34}{26001} \quad \text{whence} \quad \gamma = 000026$$

38 The specific gravity of a metal at 0°C is 5 Find its value at 100°C referred to water at 0°C (The co efficient of linear expansion of the metal is 0 000016) [*Ans* —4 976

Expansion of Liquids —

The relation between the co-efficient of absolute and the apparent expansion of a liquid is given by

$$\gamma = \gamma' + g, \text{ where}$$

γ = co-efficient of absolute expansion of liquid
γ' = apparent
g = expansion of the containing vessel

EXAMPLES —

39 The co-efficient of absolute expansion of mercury being 1/5550 and its co-efficient of expansion relative to glass being 1/6480, find the co-efficient of expansion of glass [*Ans* —0 000259

40 A glass vessel holds when quite full at the temperature of melting ice 20 cub in How many ounces of boiling water will it hold? (γ for glass is 000026)

$$V_t = V_0\ (1 + \gamma t)$$
$$= 20\ (1 + 000026 \times 100) = 20\ 052 \text{ cub in}$$

Now wt of 1 cub ft of water is 1000 ozs

$$\text{,, } 20.052 \text{ cub. in ,, } \quad \frac{20.052 \times 1000}{12 \times 12 \times 12} = 11.6 \text{ ozs}$$

41 A solid at 0°C, when immersed in water, displaces 500 cub in, at 30°C it displaces 503 cub in Find its mean co-effiecient of expansion between 0° and 30°C [*Ans* —0.000066.

42 Mercury is placed in a graduated glass tube and occupies 100 divisions of the tube Through how many degrees must the temp be raised to cause the mercury to occupy 101 divisions ?

$$\begin{aligned}
\text{Now } \gamma \text{ for mercury} &= .00018 \\
g \text{ for glass} &= .0000254, \\
\gamma' \quad \text{,,} &= (\gamma - g) = .000154
\end{aligned}$$

$$\begin{aligned}
\text{Again } V_t &= V_0(1 + \gamma' t) \\
101 &= 100\,(1 + .000154 t) \\
1 &= 0.0154 t \qquad Or \quad t = 64°.93C
\end{aligned}$$

43 An iron bottle contains 20 lbs of mercury at 0°C but at 100°C it only contains 19.72 lbs α for iron being 0.000012, find γ for mercury

Here the volume of the bottle as also that of mercury does not change while the density of mercury alone changes

Then we have

$$\begin{aligned}
& V\rho = V\rho_0\,(2 - \gamma' t) \\
\text{Or} \quad & 19.72 = 20\,(1 - 100\gamma') \\
\text{Or} \quad & 2000\gamma' = 0.28 \\
\text{Hence} \quad & \gamma = 0.00014 \\
& \gamma = \gamma' + g = .00014 + .000036 = 0.000176
\end{aligned}$$

44 In an experiment, a piece of glass weighing 45 gms in air was found to weigh 30 gms in water at 4°C and 30.32 gms in water at 60°C Find γ for water, taking that of glass as .000024

Loss in wt of glass in water at 4°C

$$\begin{aligned}
&= (45\text{-}30) \text{ gms} && = 15 \text{ gms} \\
\text{Vol of glass at } 4°C & && = 15 \text{ cc}
\end{aligned}$$

At 60°C this volume becomes

$$\begin{aligned}
15\,(1 + 0.000024 \times 56) &= 15 \times 1.001344 \\
&= 15.02016 \text{ cc}
\end{aligned}$$

Loss in wt in water at 60°C

$$=(45-30\ 32) \text{ gms} = 14\ 68 \text{ gms}$$

i e 14 68 gms of water at 60°C occupies 15 02016 *c c*

Density of water at 60°C

$$=14\ 68/15\ 02016$$

which again $= 1 - 56\ \gamma$

Or $\gamma = 00041$ app

45 The co-efficient of cubical expansion of mercury is 000180 and of brass 000060 per 1°C Find the atmospheric pressure in inches of mercury at 0°C when a barometer with a brass scale (correct at 62°*F*) reads 30 in at a temp of 50°*F*

$$62°F = 16°\tfrac{2}{3}C \text{ and } 50°F = 10°C$$

Since the brass scale is correct at 16⅔ C, its true height at 10°C

$$=(1 - 00002 \times \tfrac{20}{3}) \text{ where}$$

$20/3 = \text{Diff in temp} = 16^2/_3 - 10$

$00002 = \text{Lin co-efft for brass} = 00006/3$

$$=29\ 996 \text{ in} = \text{true reading at } 10°C$$

Again the height of mercury at 0°C that ocupies a length of 29 996 at 10°C is

$$29\ 996 = h_0\ (1 + 00018 - 10)$$

when $h_0 = 29\ 942$ in

and this is the required atmospheric pressure at 0°C

46 A glass flask which holds 100 gms of a given liquid at 20°C holds 98 gms of the same liquid at 100°C Find the co-efficient of expansion of the liquid neglecting that of the glass [*Ans* —000255

47 A weight thermometer contains 17 67 gms of mercury at 15°C and only 174 4 at 100°C calculate the apparent expansion of mercury [*Ans* —0 000155

48 The apparent co-efficient of expansion for mercury glass is 000154 Find the mass of mercury that overflows from a weight thermometer containing 360 gms of mercury at 0°C when the temp rises to 98°C [*Ans* —5.35 gms

at 60°C is 0 98' find the co-
between 4°C and 60°C if the
re be unity [*Ans* —0 0003

ccupies 8 0144 cub inches at
which the volume is increased

Dulong and Petit's apparatus
1 of mercury the hot column
column at 0°C The height of
id that of the cold column was
expansion of mercury

$$\frac{9}{5000} = 00018$$

L.n. ... of Gas ... -

... Law

$V = V_0(1+\gamma t)$ where

V_0 = vol of any gas at 0°C
V = ,, ,, ,, , t°C
γ = co efft of expan of gas = 1/273 app

Hence increase in volume = $V_0\gamma t$

EXAMPLES —

52 A certain quantity of gas measures 100 *cc* at 0°C, Find its volume at (i) 100°C (ii) 150°C (iii) 300°C

$$V_{100} = V_0\left(1+\frac{100}{273}\right)$$

$$= 100\left(1+\frac{100}{273}\right) = 137\ cc$$

53 A litre of hydrogen, at 10°C is heated at constant pressure to 283°C Find its volume [*Ans* —2 litres

54 A certain quantity of gas occupies a volume of litres at 21°C - Find the volume at 0°C [*Ans* —26 litres

55 A litre flask contains 0 9487 gms of air at 100°C How much will it contain at 0°C. [*Ans* —1 293 gms

56 Find the change of volume produced by heating 91 *c c* of a gas from 0°C to 24°C

Change in Vol $= V_0 \gamma t = 91 \times \frac{1}{273} \times 24 = 8$ *c c*

57 To what temp must a gas be heated in order that its volume may become double of what it is at 0°C [*Ans* —273°C

Here $V_t = V_0 (1 + \gamma t) = 2 V_0$

58 A quantity of air measures 285 *c c* at 77 6°C Find the temp when is volume will be 230 *c c* [*Ans* —10°C

59 The volume of a certain quantity of air at 10°C is 130 *c c* and the volume at 31°C is 140 *c c* Find γ

$$V = V_0 (1 + \gamma t)$$

$$\text{Here } 140 = 130 (1 + 21\gamma) = 130 + 21 \times 130\gamma$$

$$\gamma = \frac{10}{21 \times 130} = \frac{1}{273}$$

60. 1 gm of Hydrogen occupies 11 16 litres at 0°C and at 30°C it occupies 12 39 litres under the same pressure Find γ [*Ans* —1/273.

Charles' Law in Absolute Temperature —

$$V = V_0(1 + \gamma t) \qquad \text{where } V - \text{vol at } t°\text{C}$$

$$V' = V_0(1 + \gamma t') \qquad ,, \quad V' - \text{vol at } t'°\text{C}$$

$$\frac{V'}{V} = \frac{1 + \gamma t'}{1 + \gamma t}$$

$$= \frac{1 + t'/273}{1 + t/273} = \frac{273 + t'}{273 + t} = \frac{T'}{T}$$

where T and T' are temperatures measured on the Absolute scale

Thus we have

$$\frac{V}{T} = \frac{V'}{T'}$$

EXAMPLES —

61 1000 *ccs* of air weigh 1 293 gm at 0°C and 0 9487 at 100°C Calculate γ for air from these data.

$$V = \frac{M}{\rho} = \frac{M'}{\rho'}$$

$$\frac{M'}{M} = \frac{\rho'}{\rho} = (1 - \gamma t), \text{ for } \rho' = \rho(1 - \gamma t)$$

Then we have $\frac{0\ 9487}{1\ 293} = (1 - 100\gamma)$, whence $\gamma = 0\ 0036$

62 Supposing that a quantity of gas were to occupy 500 *c c* at 80°C and 550 *c c* at 120°C, what would be the mean γ for the gas between 80° and 120°C [*Ans* —1|400,

63 Find the density of air in a furnace whose temp is 1200°C , the density of air at 0°C is 0 001293 [*Ans* — 000243

64 300 *c c* of air is measured at 27°C what will be the volume at 40°C, the pressure remaining cons ? [*Ans* —313 cc

$$\frac{\text{Vol at } 40^\circ\text{C}}{300} = \frac{273+40}{273+27}$$

65 12 38 litres of air weigh 1 gm at 30°C Find its volume at 50°C [*Ans* —13 2 cc

66 A quantity of gas measured at 0°C and 760 mm has a volume of 354 c c Find the volume at 27°C and 740 mm

We have $\frac{PV}{T} = \frac{P'V'}{T'}$

i e $\frac{354 \times 760}{273} = \frac{740 \times V}{300} = 400$ c c app

67 A quantity of air occupies a volume 0 8026 litre at 100°C and 609 mm pressure Find its volume

(i) at N T P

(ii) 100°C and 752 mm

(iii) —50°C and 760 mm

[*Ans* —(i) 1 (ii) 1 38 (iii) 0 8168 litres

68 A quantity of gas occupies 580 c c at 17°C and 780 mm pressure What would be the volume at 30° if the pressure remains constant ? [*Ans*—606 c c

69 The temp of a quantity of air collected at N T P, is increased to 7° 18 C To what the pressure must be changed so that the volume may regain its original value ? [*Ans* —78 cm

70 A gramme of gas at 27°C has the pressure on it halved and is then cooled until it occupies the same volume as the first What is its final temperature ? [*Ans* —123°C

71 A mass of air under a given pressure occupies 44 cub in at a temp of 13°C If the volume of the air be reduced to 24 cub in, and the temperature raised to 39°C, show that the pressure will be doubled

72 A cubic foot of dry air weighs 540 gr at 14°C and 30 in pressure Show that an equal volume of air will weigh about 535 gm at 7°C and 29 in pressure

73 A quantity of gas is collected in a graduated tube over mercury The volume of the gas at 10°C is 50 cc and the level of mercury in the tube is 10 cms above the level outside, the barometer stands at 75 cm Find the volume which the gas would occupy at 0°C and 76 cm barometric pressure

$$\frac{PV}{T}=\frac{P'V'}{T'}$$

Here $P=(75-10)=65$ cms

Also $V=10$ and $T=(273+10)=283$

$P'=76$ and $T'=273$

Or $\frac{65\times 50}{283}=\frac{76\times V'}{273}$ whence $V'=41\ 25$ cc

74 Determine the height of the barometer when a milligram of air at 23°C occupies a volume of 20 cc in a tube over mercury, the mercury standing 73 cms, higher inside the tube than outside [*Ans* —76 23 cms

75 3 cc of air at atmospheric pressure is introduced into the space above the mercury in a barometer, reading 760 mm originally The volume of air measures 4 cc Find the depression of the mercury column [*Ans* —190 mm

16°C and 30 6 in pressure a quantity of gas 3 cub in, find its volume at 2°C and 29 7 in

[*Ans*—150 cub in.

quantity of gas occupies 40 cub in at a pressure of nd temp 32°C Find the pressure if the volume is 8 cub in and the temp to 5°C [*Ans* —28 9 in

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Specific Heat —

ecific heat of a body is a ratio It is the ratio of ty of heat absorbed by an unit mass of the for unit rise of temperature to that taken by 1 r to be raised through 1°C

t m = mass of a body
s = its sp ht
t = its initial temperature
T = its final high temp

eat absorbed by the body in rising from $t°$ to $T°$

$$= ms\,(T-t) \text{ calories}$$

N B—The same amount of heat will be liberated by the body in cooling from $T°$ to $t°$

EXAMPLES —

78 100 gms of water at 50°C is mixed with 10 gms of water 0°C Find the resulting temperature [*Ans*—45° 45C

79 A body of 10 gm is heated to 100°C and is then dropped into 40 gms of water at 10°C Find the resulting temperature, the specific heat of the body being 0 01,

Let t be the resulting temperature Then
Heat *lost* by the body in falling from 100°C to t°C
= Heat *absorbed* by water in rising from 10°C to t°C
Or $10\times\ 01\,(100-t)=40(t-10)$

$$t=9°\ 8\ \text{C}$$

80 Calculate the amount of heat required to raise 50 gms of a metal from a temp of 30° to 100°C and find the resulting temp if the metal is then dropped into 10 gms of water at 20°C The specific heat of the metal is 0 1

[*Ans* —350 heat units, 46°6C.

81 A body of mass 10 gms at 100°C is dropped into 10 gms of water at 45°C and the resulting temp is 50°C Find the specific heat [*Ans* —0 1

82 2500 gms of a substance at 95° when put in 3000 c.c of water at 15°C, produce a rise of temperature of 6°8C Find the specific heat [*Ans* —0 112

Water-equivalent.—

The water-equivalent of any body is the mass of water whose thermal capacity is equivalent to that of the body Thus if w denote the water-equivalent of a vessel, of mass m and specific heat s, we have

$$w \times 1 = m\ s$$

or $$w = ms$$

EXAMPLES —

83 Into a calorimeter whose temp is 15°C is placed 34 gms of water at a temp of 50°C The temp of the two becomes 20°C What is the water-equivalent of the calorimeter?

Let w be the water-equivalent of the calorimeter

Here mass of water	= 34 gms
Initial temp of calorimeter	= 15°C.
Temp of hot water	= 50°C
Final temp of water and cal	= 20°C

Now, Heat lost by water = Heat gained by calorimeter

Or mass of water × its fall of temp-

= w × rise of temp of cal

i e 34 (50—20) = w(20—15) whence w = 204 gms

84 What do you mean by (1) an unit of heat (2) specific heat of copper = .092 (3) Latent Heat of steam = 536 ?

85 A copper calorimeter, of specific heat 0 095 has a mass of 120 gms and contains 280 gms of water at 15°C Find the specific heat of a substance when 375 gms of it at a temp of 100°C when immersed raises the temp of the water to 25°C [*Ans*—0 1036

86 The weight of a copper calorimeter is 110 gms and the specific heat of copper is 0 095 400 gms of water at a temperature of 16°C are put into the calorimeter and 60 gms of

d to 98°C is also dropped into
ubstance, the resulting temp

Then

e = 60 × (98—21) × S calories

1—16) calories
110 × 095(21—16) calories
5 × (100 + 10 15) calories
45

1 718 gm at 98°C is put into
water at 15°C and the temp
is 21 °C , the weight of the
heat of copper [Ans—0 095

specific heat of silver a piece
is heated to 98°C and then
ining 100 gms of water at
ture is 11°C Find the specific
heat of the silver, the water-equivalent of the calorimeter etc, being 3 6 [Ans—0 057

89 Determine the specific heat of copper from the following data— [Ans—0 09

Weight of copper		= 16 65 gms
Weight of water in calorimeter		= 49 gms
Initial temp of copper		= 99 °5C
,, ,,	water in calorimeter	= 12 °0C
Final ,,	of mixture	= 14 °5C
Water equivalent of calorimeter, etc		= 2 1 gms

90 Determine the specific heat of alcohol from the following data — [Ans—0 615

Weight of copper calorimeter		= 20 48 gms
,, ,, ,,	+ alcohol	= 70 5 ,,
,, ,,	dropped in calorimeter	= 10 5 gms
Initial temp of cal + alcohol		= 10°C
,, ,,	copper	= 98 0°C
Final ,,	mixture	= 12 6°C

91 A quantity of turpentine 250 gms in weight is enclosed in a copper vessel whose mass is 25 gms and is heated to 100°C On immersing the whole in 535 gms of water at 13°C in a copper calorimeter 110 gms in mass the temp rises to 27 5°C Assuming the specific heat of copper to be 0 1, find that of turpentine [*Ans*—0 427

92 A mass of 200 gms of platinum at 90°C is placed in 100 gms of turpentine within a copper calorimeter whose mass is 30 gms and temp 15°C The final temp of the whole is 21 7°C Find the specific heat of the liquid, if that of the copper be 0 96 and platinum 032 [*Ans* —0 46

93 A mass of 200 gms of copper whose specific heat is 0 095 is heated to 100°C and placed in 100 gms of alcohol at 8°C contained in a copper calorimeter whose mass is 25 gms and the temp rises to 28 5°C Find the specific heat of alcohol

(1) Heat given out is that from 200 gms of copper when its temp falls from 100°C to 28° 5C

$$= 200 \times 095 \times (100 - 28\ 5)$$
$$= 19 \times 71\ 5$$
$$= 1358\ 5 \text{ calories} \quad (1)$$

(2) Heat absorbed is divided into two parts —

(*a*) that absorbed by calorimeter weighing 25 gms when the temp rises from 8°C 28° 5C,

$$= 25 \times .095 \times 20.5 = 48\ 7 \text{ calories} \quad (a)$$

(*b*) that absorbed by 100 gms of alcohol of specific heat S when the temp rises from 8°C to 28 5°C

$$= 100 \times 8 \times 20\ 5 = 2050\ S \quad (b)$$

Now $(1) = (a) + (b)$

$$1358\ 5 = 48\ 7 + 2050\ S \qquad \text{whence} \quad S = 0\ 639$$

94 If the heat evolved by 1 kg of water in cooling down from 100°C to 0°C were employed in heating 10 kg of mercury initially at 20°C, to what temp would the mercury be raised? (Specific heat of mercury = 033) [*Ans.*—292° 5C

95 A piece of platinum weighing 10 gms is taken from a furnace and plunged instantly into 40 gms of water at 10°C The temperature of the water rises to 24°C What was the temperature of the furnace? (Specific heat of platinum = 032) [*Ans.*—1774°C

3°C is put into an iron vessel con-
. 'C and the temp of the water, ball
ent is 21°C, the weight of the vessel
, the weight of the vessel being 1
all (Specific heat of lead = 384, of
[*Ans* —52 4 *lbs*

density of boiling water is 0·96 and
o°C is 13 6, calculate the resulting
of boiling water and mercury at o°C
[*Ans* —67°9C

100°C and dropped into 10 lbs of
of the water by 5°C What effect
had there been 15 lbs of water at
[*Ans* — a rise of 2° 4C

Change of State and Latent Heats —

which heat is applied, begins to
ature, called its *Melting Point*,
ferent substances The tempera-
the fusion is finished A similar
quid is passing into the gaseous
nt

sion or of Vaporisation of a body
absorbed by 1 gm of the body to be
gaseous state respectively *without*

at o°C are converted into water at
heat absorbed ?

requires 79 5 units of heat

5 × 100 = 7950 units

are converted into ice What is the
[*Ans* —3180 units

heat will be given out by 20 gms
converted into ice at o°C ?
[*Ans*—15900 units

102 How much mercury at 20°C would be required to melt 1 kg of ice at 0°C, the specific heat of mercury being 0 033? (Latent heat of fusion of ice = 79 5)

Let m be the weight in kilogrammes of mercury reqd

Heat lost by mercury = Heat gained by ice

i.e $m(20-0) \times 0\ 033 = 79\ 5 \times 1$, whence $m = 120\ 5$ kg

103 How much ice at 0°C will be melted by 100 gms of boiling water? [*Ans* —123 gms

104 How much boiling water at 100°C will just melt 625 gms of ice? [*Ans* —500 gms

105 How much ice at 0°C would 1 kgm of steam at 100°C melt, if the resulting water was at 0°C? [*Ans* —7 95 *kg*,

106 1 kg of ice at 0°C is placed in 5 kg of water at 0° and 1 kg of steam at 100°C is passed into it What will be the temp of water, if no heat be lost by conduction or radiation?

Let θ be the final temp of the mixture

(i) Heat given out by 1 kg of steam at 100°C in condensing to water at $100^\circ = 537 \times 1000$ units

(ii) Heat given out by water at 100° in falling from 100°C to 0°C $= 1000\ (100-\theta)$

(iii) Heat absorbed 1 kg by of ice at 0° to melt into water at 0°C $= 79\ 5 \times 1000$ units,

(iv) Heat absorbed by 6 kg of water at 0°C in rising from 0° to θ°C $= 6 \times 1000(\theta-0)$,

As heat given out = heat absorbed, we have

$1000 \times 537 + (100-\theta) \times 1000 = (79\ 5 + 6\theta) \times 1000$

Then $7\theta = 557\ 5$ or $\theta = 79\ ^\circ 6$C

107 A mass of iron weighing 400 lbs and whose temp, is 440°C and specific heat 0 114 is placed in a mixture of ice and water How much ice will be melted, if the latent heat of ice is 79 5? [*Ans* —252 3 lbs

108 How many units of heat would cause a mixture of ice and water to contract by 50 cc, if 100 cc, of water at 0°C becomes 109 cc on freezing?

100 *c c*, of water becomes 109 *c c* on freezing

in this occurs a change of 9 *c c*

100 cc of water gives up

$100 \times 79\ 5 = 7950$ units of heat

... traction of 9 cc 7950 units are given out

t given out on a contraction of 50 cc

$$= \frac{50 \times 7950}{9} = 44166\ 6 \text{ units}$$

ture of ice and water is reduced in volume by re What weight of ice has been melted?

[*Ans* —11 05 gms.

specific gravity of ice is 0 917 10 gms of a are immersed in a mixture of ice and water, of the mixture is found to be reduced by 125 ge of temp Find the specific heat of the metal

he specific heat required

given out by the metal $= 10 \times 100 \times S$

$= 1000\ S$ calories

vol of 1 gm of ice at 0°C $= 1/0\ 917$

$= 1\cdot0905$ cc

of 1 gm of water at 0°C $= 1$ cc

tion of volume when 1 gm of ice is converted ter at 0°C $= 0\ 0905$ cc

s of ice to undergo a contraction of 0 125 cc.

$$= \frac{125}{0905} = \frac{125}{90\ 5} \text{gms.}$$

bsorbed by $125/90\ 5$ gms of ice

$$= \frac{125}{90\ 5} \times 79\ 5$$

sorbed = Heat gained

$79\ 5 = 1000\ S,$ whence $S = 0\ 197$

me of ice at 0°C contracts 0 091 cc in beco- A piece of metal weighing 10 gms is heated n dropped into the calorimeter The total 53 cc Find the specific heat of the metal, heat of ice as 80

[*Ans* —0 1108

112 Determine the Latent Heat of ice from the following data.— [*Ans* —80

Weight of brass calorimeter (sp heat 0 01)	—30 gms
" " " + water	—1127 gms
Initial temp of water and cal	—24°C
Final " " "	—14°C
Weight of calorimeter etc after addition of ice	—1137 gms

113 Determine the Latent heat of ice from the following data — [*Ans* —79 5

Water eqt of calorimeter (sp heat 0 1)	—3
Weight of calorimeter + water	—533 gms
Initial temp of water and cal	—50°C
Final temp of water and cal	—20°C
Wt of calorimeter etc, after addition of ice	—543 gms

114 Find the result of mixing

(i) 10 gms of water at 40°C with 1 gm of ice at 0°C

(ii) 2 gms of ice at 0°C with 5 gms of water at 20°C

Examples of this kind should be put to a *preliminary* examination in order to ascertain whether the whole of the ice or only a part of it will be melted This may be ascertained from the following consideration —

(i) In example (1) above, the number of units of heat required to melt 1 gm of ice = 80

Now 10 gms of water evolve in cooling from 40°C to 0°C = 40 × 10 = 400 units of heat

Since 400 > 80, it is evident that the whole of the ice will be melted Then the ice will take up only 80 units of heat out of the water and the resulting temp will be higher than 0° Let this temp be t°C

Then (i) Heat given out by water $= 100 \times (40 - t)$,

and (ii) Heat absorbed by ice at 0°

(*a*) in melting into water at 0° $= 80 \times 1 = 80$ units

(*b*) in rising from 0° to t°C $= t$ units

But Heat given out = Heat absorbed

i,e, $10 \times (40 - t) = 80 + t$

Or $t = 34$°C

The result is 11 gms of water at 29°C,

portion of ice will be melted, since
(in falling to $0^\circ C$ evolves 100 units
water at $0^\circ C$ in being converted to
$\times 80 = 160$ units of heat only

ly a part of ice will melt, the temp
(

ity of ice melted
q whence $q = 1\ 25$ gms

esult of placing (*a*) 5 lbs of copper
er at 80° C in contact with 1 5 lb
opper = 0 1)

ice will melt
ill melt and the resulting temp
will be 26° 6C

(is put into 10 lbs of water at
mp ? [*Ans* —16° 8C

- $10^\circ C$ are mixed with 120 gms
inal temp of the mixture
[*Ans*—$67^\circ C$

water at $60^\circ C$ are poured into a
copper calorimeter of mass 26 gms containing 5 gms of water at $10^\circ C$ 8 gms of ice at $-5^\circ C$ is then dropped in the mixture Find the resulting temperature [*Ans* —31 $^\circ 3C$

126 Find the Latent heat of steam from the following data—

Weight of calorimeter (sp heat 092)	—80 gms
Wt ,, ,, ,, and water	—180 gms
Initial temp	—$10^\circ C$
Final temp	—$80^\circ C$
Wt of water + cal after the expt	—193 42 gms
Temp of steam	—$100^\circ C$

From the above we have—

Water equivalent of calorimeter $= 80 \times 09 = 7\ 2$
Wt of water in calorimeter $= 100$ gms
Wt of steam condensed $= 13\ 42$ gms

Now Heat given out by steam = Heat gained by water
Or $13\ 42 \times L + 13\ 42\ (100 - 80) = (100 + 72) \times 70$
Or $13\ 42\ L = 7235\ 6$ $\quad L = 548$ units

119 A calorimeter whose water-equivalent is 48 gms, has 552 c.c. of water in it and the whole weighs 882gms. Into this steam at atmospheric pressure is condensed till the temp. rises from 12°.2 to 18°.7 C and on weighing again the calorimeter weighs 886.2 gms. Calculate the latent heat of vaporisation of water. [*Ans.*—537.7

120 It is found that one pound of steam at 100°C when passed into 15 lbs. of water at 0°C raise the temp. of the water to 40°C. Calculate the latent heat of steam. [*Ans.*—540

121 A mass of 200 gms of copper (sp. heat 0·1) is hung in a closed chamber at a temp. of 15°·5C. Steam is then admitted at the normal atmospheric pressure. Calculate the mass of water condensed by the copper, the latent heat of steam being 536.

Heat taken up by the copper in rising from 15°.5C to 100°C (the temp. of the steam)

$$= 200 \times \cdot 1 \times (100 - 15.5)$$
$$= 1690 \text{ units}$$

This heat is given out by x gms of steam in being condensed to x gms of water at 100°C.

$$536\,x = 1690 \text{ units} \quad \text{Or} \quad x = 3.15 \text{ gms}$$

122 Steam at 100°C is passed into a copper calorimeter weighing 100 gms. and containing 500 gms. of water at 15°C until the temp. of the calorimeter and its contents rise to 25°C. Calculate the weight of steam condensed. Given the specific heat of copper = 0.1 and latent heat of steam = 536.
[*Ans.*—8.34 gms

123 15 gms. of steam are blown into 80 gms. ice-cold water at 0°C. Find the rise of temp. produced. The water equivalent of the calorimeter is 15 gms. latent heat of steam is 536. [*Ans.*—86°.7C

124 If 25 gms of steam at 100°C be passed into 300 gms of ice-cold water what will be the temp. of the mixture? The latent of heat of steam is 536. [*Ans.*—48°.9C.

125 A vessel containing 10 gms. of ice is held over a flame. How much heat will be required to melt the ice and vaporise it completely? Latent heat of ice = 80, of Steam = 536. [*Ans.*—7160 units

Vapour Pressure —

ke a gas, exerts pressure

ated vapour obeys Boyle's law and Charles's
urated vapour does not obey these laws

oils only when its vapour pressure equals the
pressure

-

c of oxygen saturated with water are collected,
740 mm and a temp of 15° C Find the
oxygen at 0°C and 760 mm having given that
essure of aqueous vapour at 15°C is 12 7 mm

essure of the mixture

= pressure of oxygen + pressure of aqueous vapour

ure of oxygen = 740—12 7 = 727 3
of oxygen = 100 cc
ature ,, = 15°C = 288 absolute

...pp y $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

Substituting, $\frac{727\ 3 \times 100}{288} = \frac{760 \times V_2}{273}$

whence $V_2 = 90\ 7$ c c

128 The boiling point of water at the sea-level is 100°C and at a higher level is 90°C, the temperature of observation at the two places being 11°C, and 5°C respectively Find the difference in level (The density of dry air at 0°C and 760 *mm* is 001293)

From the table, knowing the boiling point we can get the atmospheric pressure at the two places and these are here 760 *mm* and 525 *m m* respectively Then the mean pressure

$= (760 + 525)\frac{1}{2} = 642\ 5$

and the difference of pressure is $= (760—525)$

$= 235$ *m m*

$= 23\ 5$ cms

The mean temp is 8°C

Again, a column of mercury 1 sq cm cross-section and 23 5 cm high weighs $13\ 6 \times 23\ 5$ gms $= 319\ 6$ gms

and this is the mass of a column of air 1 sq cm in area between the two stations Again, the density of air at the mean pressure and temp *i e*, at 642 5 *m m* and 8°C

$$= \frac{001293 \times 642\ 5 \times 273}{760 \times 281} = 00106 \text{ gms}$$

Hence the difference in level

$$= \frac{\text{mass of the air column}}{\text{average density}} = \frac{319\ 6}{00106} = 3015\ 09 \text{ m}$$

120 1 litre of dry Hydrogen at 0°C and 760 mm weighs 0 08936 gm Find the weight of 1 litre of Hydrogen collected over water at 20°C (Vapour Pressure at 20°C = 17 39 mm)

[*Ans* —0 099

130 Calculate the hygrometric state of air from the following data — [*Ans* —0 899.

Actual temp —14° 5C
Temp at which dew appears —9° 2C
Vapour Tension of water at 5°—·0087 mm
" " " 10°C— 0122 "
" " " 15°C— 0169 "

Mechanical Equivalent of Heat.—

From the principle of conservation of energy we know that the various forms of energy may though not always at will, be transformed one into another

Thus when work is transformed into heat,—the quantity of heat produced is equivalent to the amount of work expended in its production, and conversely, when heat is transformed into work the amount of work produced is equivalent to the quantity of heat expended in its productions but work is expressed in ergs and heat in calories, hence in order to transform one system into the other we multiply the quantity of heat by a constant J which is called the *Mechanical equivalent* and is equivalent to the *work done in producing unit quantity of heat* Thus in all cases we have $W = JH$

what height must a block of lead fall in order
erature raised through 10°C (Specific heat of
the value of J being 4 2 × 10^7) [*Ans* —3 9405

e of length l cms is closed by two tightly fitting
f small lead shots at t°C are poured into the
being closed and held vertical It is then
the shots fall along the whole length of the
eration is repeated n times Then the shot
rom the tube, the temp of the former (*i e* of
d and is found to be t'°C Determine J

=weight of lead shot in grammes

=distance in cms the shot falls each time

=number of times the tube is inverted

=rise of temperature in centigrade degrees

=specific heat of lead

rk done by gravity

$= n \times m \times l$ gm cms units

Heat gained by lead $= m \times s \times (t'-t)$ calories

$$J = \frac{nml}{ms(t'-t)} = \frac{nl}{s(t'-t)}$$

133 Calculate J from the following —

Weight of lead	—434 gms
Specific heat of lead	—0 0315
Vertical height of fall	—67 7 cms
Rise in temperture	—2°C
Number of inversions	—40

[*Ans* —4 4 × 10^4

CHAPTER IV.

LIGHT

In all cases of working out examples on Light students are advised to draw diagrams with black-lead pencils

Shadows —

Shadows are of two kinds viz , *Umbra* and *Penumbra*

When the luminous source is a point, only umbra is formed , while both the umbra and penumbra are formed when the luminous source has a size

EXAMPLES —

1 A man $5\frac{1}{2}$ ft high is standing at a distance of 10 ft from a street lamp 11 ft high Find the length of the man's shadow upon the ground [*Ans* —10 ft

2 The diameter of a circular uniform source of light is 3 inches and it is placed at a distance of 20 ft from a sphere of 3 inches diameter Find approximately the diameter of the umbra and penumbra cast on a screen 10 ft beyond the sphere

Draw a figure first

Diameter of source of light	= 3 in
" " sphere	= 3 in
Diameter of umbra	= 3 in
Internal diameter of penumbra	= 3 in
External " " "	= 6 in

3 Outside a small hole in the wall of a dark room 10 ft square is a tree 15 ft high and distant 56 ft from the wall. The image of the tree falls on the wall of the room Determine the height of this image [*Ans* —2 7 ft

Velocity of Light —

Light travels through space with an immense velocity of 186,000 miles per second

ıutes to travel across the earth's
is 296, 000, 000 kilometres or 184,
ıe velocity of light
ıns —299,000 km or 186,000 miles

e earth is 8000 miles and that of
The earth is 93,000,000 miles from
of the earth's umbra ?
[*Ans* —9401 miles

or light to come from the star Sirius
is the star ? [*Ans* —4 9 $\times 10^{11}$ miles

= 20 years in sec , × vel of light

distant 600,000,000,000,000, miles
ıde suddenly, how long would it be
tect the fact ? [*Ans* —3 2 $\times 10^{10}$ secs

Photometry

nation at a point illuminated by a
r I, at a distance r from it, is given
by $P = I/r^2$

As I is constant for the same source of light, $P \propto 1/r^2$ This is known as the *Law of Inverse Squares*

Again if another source of light of illuminating power I′ is placed at a distance r' from the same point so as to produce an equal illumination at the point, we have

$$P = I'/r'^2$$

Or $$\frac{I}{r^2} = \frac{I'}{r'^2}$$

Or $$\frac{I}{I'} = \frac{r^2}{r'^2}$$

This is the law of *Direct Squares* or the Principle of Photometry

EXAMPLES—

8 Two sources of light of candle powers 2 and 6 respectively are placed at distances 4 and 10 cms on either side of a

cardboard screen Compare the illumination on the two sides of the screen

$$\text{Illumination due to the first} = \frac{I}{r^2} = \frac{2}{4^2} = \frac{1}{8}$$

$$\text{,, \quad ,, \quad ,, second} = \frac{I'}{r'^2} = \frac{6}{100} = \frac{3}{50}$$

Their ratio $\frac{1}{8} \quad \frac{3}{50} = 25 \quad 12$

9 Compare the intensity of illuminaion at a place due to (i) a gas lamp of 500 C P placed 10 ft high and (ii) an arc lamp of 1200 C P placed 60 ft high [*Ans* —15 1

10 A standard candle and a gas flame of 9 candle-power are placed 20 cms apart Find where must a screen be placed between them so that the latter may be equally illuminated by each

Let x be the reqd distance as measured from the standard candle Then its distance from the gas flame is $(20-x)$ cms Then for equal illumination on the screen due to each we must have

$$\frac{1}{x^2} = \frac{9}{(20-x)^2}$$

$$20 - x = \pm 3x$$

$$x = +5 \text{ or } -10$$

Now corresponding to the two values of x there are two positions where the screen may be placed, one of these is 5 cms to the right of the standard candle *i e* between the candle and the gas flame, while the second is -10 cm to the left of the candle

11 Two lamps of 8 and 32 c p are fixed 120 cms apart Where on the line joining them must a screen be placed so as to be equally illuminated by each ? [*Ans* —40 cm , 120 cm

12 A gas flame of 16 c p and a lamp of 9 c p are placed 140 cms apart Where must a screen be placed between them so as to be equally illuminated by each ? [*Ans* —Bet the two flames & 60cm from 9 c p lamp 420 cm

ed 1 metre from a surface At
of 16 c p be placed so as to
of the surface? [*Ans* —1 26 m

A and *B* placed 100 cms apart
of a photometer *A* having 4
ie position of the screen so that
[*Ans* —Dis from A = $66\frac{2}{3}$ cm.

e, if a semi-transparent sheet
ight falling upon it be placed
urce *B*, in what direction and
reen be moved in order that its
d?

een be moved to a distance *d*

A is $100 - d$

ice the semi-transparent sheet
t from *B*, only 4/9 ths of its
Hence we have

$$= \frac{4/9 B}{d^2}$$

$$= \frac{1}{3a} \qquad \text{whence } d = 25 \text{ cms}$$

lamp falls on a silvered mirror
Grease-spot photometer The
screen *via* the mirror is 15 cms
of the light falling on it, where
n order that the grease-spot shall
[*Ans*—7 9 cm

Reflection at a Plane Surface —

a plane reflecting surface, the
surface at the point of inci-
all in one plane

ion is equal to that of incidence

The image formed by a plane mirror is *virtual*, equal in size to the object, laterally inverted and appears to be formed behind the mirror at an equal distance from it as the object is in front of it

EXAMPLES —

17 A plane mirror distant 10 cms from an object is moved back 10 cms parallel to itself How far does the image move ? [*Ans*—20 cm.

18 The image of the moon 32° above the horizon is observed in a tranquil pool Find the angles of incidence and reflection

Angle of incidence $= 90° - 32° = 68° =$ angle of reflection

19 What is the deviation produced by reflection on a plane mirror when the angle between the incident and the reflected ray is 60° ?

Hint—The deviation $= (\pi - 60°)$

20 A ray of light incident on one of two mirrors inclined at an angle to each other in a direction parallel to the second mirror retraces its own course after reflection at the second mirror Find the angle between the two mirrors [*Ans*—45°

Hint—The ray will have to fall normally on the second mirror

21 Find the angle between two mirrors is order that a ray incident on the first and parallel to the second may after reflection at the two be parallel to the first Illustrate your answer by a figure [*Ans*—60°

22 The number of images due to a source of light between two mirrors inclined to each other being given by the formula $\frac{2\pi}{\theta} - 1$, where θ is the inclination between the mirrors, find the number of images for the following values of θ (1) 0° (2) 10° (3) 30° (4) 45° (5) 60° (7) 90° What happens when the two mirrors are parallel ? Draw the figure in each case

[*Ans*—(i) ∞ (ii) 35, (iii) 11 (iv) 7, (v) 5, (vi) 3

Spherical Mirrors.—

between the focal length f and the
e object and its image produced by a
n by the formula

$$- \frac{1}{u} = \frac{1}{f}$$

ne radius of curvature of the mirror

be remembered that f is *positive* for a
rative for a *convex* mirror

oduced is given by

where I=linear dimension of the Image

roved to be $= \frac{v}{u}$

ject 4 inches high is placed on the
ncave spherical mirror at a distance of 15
ror Determine the position and size of
n of the mirror being 6 inches

or $v = 10$ in

here $O = 4$ in

or $I = 2\frac{2}{3}$ in

is 10 in, in front of the mirror and is 2

ne is placed 25 cms away from a concav
f curvature is 80 cms Find the positio
ge [*Ans* $v = -66\ 7$ cm

25. In what position must a candle flame be placed in front of a concave mirror of focal length 40 cms in order to give rise to an image four times as large as the object ?

We have $m=\frac{v}{u}=\frac{I}{O}=4$

$\therefore \quad v=4u$

Then $\frac{1}{4u}+\frac{1}{u}=\frac{1}{40}$ whence $u=50$ cms

Thus the candle must be placed 50 cms from the object tor the real image

Again for the *virtual* image, where v is *negative* we have

$-\frac{1}{4u}+\frac{1}{u}=\frac{1}{40}$ whence $u=30$ cms

26 Where must a candle be placed in front of a concave mirror of radius of curvature 80 cms, so that a real image five times as large as the object may be formed ? [*Ans* —48 cm

27 The linear dimension of an object placed in front of a convex mirror of 3 in focal length is twice that of the image Determine the positions of the image and the object

Here, $m=\frac{I}{O}=\frac{v}{u}=-\frac{1}{2}$ $\therefore \quad u=2v$

whence $\frac{1}{2v}+\frac{1}{v}=-\frac{1}{f}=\frac{1}{3}$ whence $u=-9/2$ and $v=9$

28 At what distance from a concave mirror of focal length f must an object be situated so that the image may be (i) of the same size, (ii) one-quarter of the size of the object ?

[*Ans* $u=2f$, $u=5f$

29 Determine the size of the image of an object held at a distance equal to its focal length in front of a convex mirror

[*Ans* —$v=\infty$.

30 At what distance from a concave mirror must an object be placed so that its image shall be magnified n times ?

The distance will depend on f, the focal length of the mirror Since the magnification is to be n times the object, we must have

$$\frac{I}{O}=\frac{v}{u}=n$$

$v=n\,u$ (numerically)

ould be taken to notice the *signs* of v and u
real image v and u are positive and $v=nu$;
age is virtual, v is negative and $=-nu$

are two solutions

ge real — In the equation

$$+\frac{1}{u}=\frac{1}{f}$$

$$v=nu$$

$$+\frac{1}{v}=\frac{1}{f}, \qquad \text{whence} \qquad u=(n+1)f/n$$

virtual —Substituting in the above equation
get

$$\frac{1}{u}=\frac{1}{f}$$

$$(n-1)/nu=\frac{1}{f} \qquad \text{whence} \qquad u=(n-1)\,f/n$$

ive mirror of 2 ft focal length is placed 1 ft
Find the change in the position of the image
ving the object 1 in nearer the mirror

24 in and $u=12$ in

$+\frac{1}{2}=2\frac{1}{4}$ whence $v=-24$ in

n the object is moved 1 in nearer, $u=11$ in

$1\frac{1}{4}=1\frac{1}{4}$ whence $v'=-20\ 3$ in

ge moves through $(24—21\ 3)=3\ 7$ inches

iat when an object is placed midway between a
ind its principal focus, the image is twice as
ct

33 An object 2 cms high is placed 1 metre away from a spherical concave mirror of 23 cms radius of curvature Calculate the height of image Will it be real or virtual ?

[*Ans* I=0 26 cm

34 An object is placed 28 cms. from a concave mirror whose focal length is 10 cms Find where the image is Is it real or virtual, erect or inverted, and what is its size, if the object be 4 2 m m broad and 14 m m long ?

[*Ans* $v=13$ 5 cm

35 Determine the size and position of the image of an object 1 in high placed 10 in from a convex mirror 20 in in radius

The focal length being one half the radius of curvature is 10 in and is here negative, the mirror being convex

Then the image is at a distance v given by

$$\frac{1}{v}+\frac{1}{10}=-\frac{1}{10}$$

Or $$v=-5 \text{ in}$$

Thus the image is virtual and is formed 5 in behind

For the size of the image we have

$$m=\frac{I}{O}=\frac{v}{u}=-\frac{5}{10}=-\frac{1}{2}$$

$$I=-\tfrac{1}{2} \text{ in}, \text{ the object being 1 in high}$$

Thus the image is ½ in long and is inverted.

36 Find the nature, position and magnitude of the image of an object placed 50 cms from a convex mirror of 15 cms focal length Verify graphically

[*Ans* —$v=150/13$ cms , I=3/13 O

37 The radius of curvature of a convex mirror is 12 cms and an object 2 cms in length is held 3 cms in front of the mirror Find the nature, position and magnitude of the image

[*Ans* —$v=$ −2 cm from O , I =4/3 cms & inverted

38 An image 2 in long is formed by a convex mirror by an object placed 12 in from it Find the focal length of the mirror, length of the object being 6 in [*Ans* —6 in

fiom a convex
l the position of
Ans , $v = -2$ in

ns in front of a
hind the mirror,
th of the mirror

e

2 cms

4 cms

35 cms in front
be 4 m m high
he focal length,
and $-35/5$ cm

igth of a mirror
ject, magnified 6
, $u = 3, f = 18/7$

ll It is required
wall State what
cal length of the
5 cms and +ve

Hence etc

each 20 cms in
it 40 cms apart
placed midway
e, if the image is
n at the concave
the object to

iave

Again, for reflection at the concave mirror

$$u=40+20/3=140/3 \qquad \text{and } f=10$$

$$\therefore \frac{1}{v}+\frac{3}{140}=\frac{1}{10} \qquad \text{or} \qquad v=140/11$$

Now for magnification, that due to the convex mirror

$$\frac{I}{O}=\frac{v}{u} \qquad i.e. \qquad \frac{I}{5}=\frac{20/3}{20}$$

And that owing to the concave mirror

$$\frac{I}{O}=\frac{I}{5/3}=\frac{v}{u}$$

Here $v=140/11$ and $u=140/3$ $\qquad \therefore v/u=3/11$

So that $\dfrac{I}{5/3}=3/11 \qquad i.e.\ I=5/11$

45. An object is placed at a distance of 8 inches from a concave mirror 1 ft. in radius. A plane mirror inclined at 45° to the axis of the concave mirror passes through its centre of curvature. Find the position of the image formed by reflection first at the concave, then at the plane mirror.

For reflection at the concave mirror we have

$$u=8 \qquad f=6$$

$$\therefore \frac{1}{v}+\frac{1}{8}=\frac{1}{6}$$

or $\qquad v=24$ in. from the concave mirror i.e. 12 inches from the plane mirror.

∴ Its image due to the plane mirror is on a line perpendicular to the axis and distant 1 ft. from the centre.

Refraction at a Plane Surface —

When a ray is passing from one medium to another its course is bent at the surface of separation of the two media. The refracted ray is turned *towards* or *away* from the normal to the surface at the point of incidence as the second medium happens to be *denser* or *lighter* than the first medium.

ablished a law on the point *viz*,

$$= \frac{\sin\phi}{\sin\phi'}$$

= relative refractive index
of the second medium

= angle of incidence

= angle of refraction

-

of light passes from one medium to a second
of incidence = 45° and an angle of refraction
refractive index for the medium [*Ans* —1 73

$\sin 45°/\sin 30° = \frac{1\sqrt{2}}{\frac{1}{2}} = \sqrt{2}$

of light is incident at 60° to the normal, upon a
surface The refracted ray makes an angle of
lected ray Find the refractive index of glass

n why a straight stick partly immersed in water
osition appears bent at the surface of the water

of light is incident on a glass plate at an angle
refractive of index of the glass is $\sqrt{3}$ Find the
ion [*Ans* —30°

ritical angle for a given medium is 60° Find
ndex for the medium

e $\frac{1}{\mu} = \sin 60° = \frac{\sqrt{3}}{2}$ $\mu = \frac{2}{\sqrt{3}} = 1\ 15$

ine of the critical angle for two media is $\frac{7}{9}$ What
the refractive index from the rarer to the denser
[*Ans* —9/7

efractive index of water and turpentine are 1 33
ctively Find the critical angle for a ray passing
water

$^{1}{}_{\beta}$ be refract index from air to another medium

" a second medium

Then $_{\gamma}\mu_{\beta}$ the refractive index from the first medium to the second is given by $_{\alpha}\mu_{\beta} - _{\alpha}\mu_{\gamma}$

∴ in this case since $_{\alpha}\mu_{\beta} = 1 \cdot 33$ and $_{\alpha}\mu_{\gamma} = 1 \cdot 47$

$_{\gamma}\mu_{\beta}$ i e the refractive index from turpentine to water

$$=\frac{1 \cdot 33}{1 \cdot 47} = \cdot 905 \text{ approx}$$

the required critical angle

$$= \text{Sin}^{-1} {}_{\gamma}\mu_{\beta} = \text{Sin}^{-1} \cdot 905 = 64^{\circ} 8'$$

53 Find the absolute refractive index for a liquid, given that the relative refractive index from the liquid to glass is 0 9 and the absolute refractive index of glass is 1 512 [*Ans* —1 7

54 Find the refractive index from glass to water from the following data —

Refractive index for air and water $= \frac{4}{3}$

" " " glass $= 1 \cdot 5$ [*Ans* —8/9

55 Explain the apparent rising of a picture stuck on to the bottom of a cube of glass so that it appears to an eye looking down as if it were in the glass If the index of refraction be 1 6, how much does the picture appear raised to perpendicular vision ?

If a be the thickness of the cube then we know that the virtual image of the picture appears raised than the object itself the distance between the object and the image being—

$a(\mu - 1)/\mu$ where $\mu = 1 \cdot 6$ from above.

∴ Substituting we get $\frac{a \times \cdot 6}{1 \cdot 6} = \frac{3}{8}a$

i e the image appears raised by 3/8 th of the thickness of the cube.

56 A rectangular piece of glass plate ($\mu = 1 \cdot 6$) is put between the eye of an observer and an object Find the alteration that takes place in the apparent distance of the object from the eye the glass plate being 5 in thick

[*Ans* —15/8 in. nearer.

filled with alcohol What
[*Ans* —4 38

ussed on a mark on the
s then interposed , the
ı for the mark to be still
, for glass ?
the plate $a=2$ in Then
'ewed through the glass

or $\mu=3/2$

n of a small trough of
t the mark is in focus ,
depth of 4 6 cms and
is 1 15 cms Find the
[*Ans* —1 3

d its refractive index is
um deviation for a ray

of light passes through a prism of angle A and in the position of minimum deviatien, then

$$\mu = \operatorname{Sin}\frac{A+d}{2} \Big/ \operatorname{Sin}\frac{A}{2}$$

where d=angle of minimum deviation

Here $A = 60^\circ$ and $\mu = 1\ 414$

Then $1\ 414 = \operatorname{Sin}\frac{(60+d)}{2} / \operatorname{Sin} 30^\circ$

or $\operatorname{Sin}(30+d/2) = 1\ 414/2 = \sqrt{2}/2 = 1/\sqrt{2} = \operatorname{Sin} 45^\circ$

whence $d = 30^\circ$

61 The angle of a prism is 60° and the minimum deviation of a ray when the prism is filled with a certain liquid is 30° Find the refractive index of the liquid [*Ans* —$\sqrt{2}$

62 An equilateral hollow glass prism is filled with a certain liquid of refractive index 1 7 Trace the path of a ray incident on the prism at an angle of 30° with the surface

Refraction through Lenses :—

The connection between the focal length f and the distances u and v of the object and its image produced by a lens is given by—

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$$

where f is positive in the case of a concave lens and negative in the case of a convex lens

Again, the magnification is given by

$$m=\frac{I}{O}=\frac{v}{u}$$

$$=\frac{\text{distance of Image from lens}}{\text{distance of Object from lens}}$$

EXAMPLES —

93 A small object 1 inch in length is placed at a distance of 3 feet from a convex lens of focal length 1 foot Where and of what size is the image? Illustrate your answer by a figure

Here $u=3$ ft and $f=-1$ ft

On substituting in the formula

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$$

We get $\frac{1}{v}-\frac{1}{3}=1$ or $v=-3/2$ ft

Again $\frac{v}{u}=\frac{I}{O}$ or $\frac{I}{1}=\frac{3/2}{3}$ i e $I=\frac{1}{2}$ in.

Thus the image is 18 in behind the lens and ½ in high

64 A small bright object is placed 10 cms away from a concave lens of focal length 20 cms Find the position of the image Is it real or virtual? [*Ans* —$6\frac{2}{3}$ cms, virtual

65 An object is placed at the principal focus of a lens where is the image? [*Ans* —at infinity

ct is placed 24 cms away in front of a convex ocal length Find where the image is

[*Ans*—$v=24$ cms

ct is placed 12 inches from a convex lens of 8 Find the position and length of the image

[*Ans*—$v=24$ cm and $I=2O$

ct 3 cms long is placed 10 cms from a con-ms focal length Find the size and nature

[*Ans*—$I=2$ cms

ct of length 2 inches is placed at a distance onvex lens of 4 inches focal length Find the th of the image [*Ans*—$v=12$ in, $I=4$ in

x lens of focal length 18 cms has an image oject placed 24 cms in front of the lens osition of the image [*Ans*—$v=72$ cms.

nvex lens of focal length f the object and same size Find the distance of the object Also determine the position of the object so rmed by the lens may, be one-half the size

[*Ans*—$2f$, $3f$

server's eye be held up close to a convex lens ngth to view an object at a distance of 25 cms ow that the magnifying power is 6

$=25$ and $f=-3$

stituting in the usual formula, we get

$$\frac{1}{25}=-\frac{1}{3} \quad \text{whence } v=-15$$

$$m=\frac{I}{O}=\frac{15}{25}=6$$

ige of a small bright object placed 20 cms med at a point 40 cms on the other side d the focal length and the nature of the lens

[*Ans*—$f=-3\frac{1}{3}$ cms

l image of an object 25 cms from a lens is me side of the lens and at a distance 8 cms nd of a lens is it and what is it's focal length?

[*Ans*—concave, $f=200$ cms

75 A circular disc 1 in diameter is placed at a distance of two feet from a convex lens and a virtual image 1 foot in diameter is formed Find the focal length of the lens

[*Ans*—$f = 24/11$ ft

76 A candle flame placed 30 cms in front of a lens is brought to a focus 8 cms behind Find the nature of the lens is brought to a focus 8 cms behind Find the nature of the lens and its focal length [*Ans*—10 9, concave.

77 The focal length of a concave lens being 20 cms, find the position of object so that its image may be $\frac{1}{5}$th its own size

[*Ans*—80 cms

78 An image magnified about 3 times is to be thrown on a screen by a convex lens of focal length 44 cms Determine the posion of the object which will give (1) a real, (2) a virtual image of the required size,

Suppose u and v to be the reqd distances of the object and the image from the lens Since the image is to be three times the size of the object its distance from the lens must be three times as great or $v = 3u$ (numerically) But since the image is to be real, it must be formed on the *opposite* side of the lens, thus v is *negative* and $= -3u$ Then in the usual equation putting $f = -44$ and $v = -3u$ we get

$$-\frac{1}{3u} = \frac{1}{u} - \frac{1}{44} \quad \text{whence } u = 58\ 7 \text{ cms}$$

Now for a virtual image we must have v positive and $= 3u$ numerically Then in the equation putting $v = 8u$ and $f = -44$, we have

$$\frac{1}{3u} - \frac{1}{u} = -\frac{1}{44}, \quad \text{whence } u = 29\ 3 \text{ cms}$$

79 A candle flame stands at a distance of 25 cms from a wall In what position must a convex lens of 3 cms focal length be placed between then so as to produce on the wall a distinct image of the candle? [*Ans*—10 or 15 cms from the wall

80 An image magnified about 4 times is to be thrown on a screen by an object distant 80 cms from the screen Determine the nature and position of the lens to be used

[*Ans* —Convex 64 cms from screen

Combination of Lenses

placed in contact,
given by—

n is combined with
the focal length of

s concave

ch is equivalent to
cms and 15 cms
[*Ans*—$f = -6$ cms

length is placed in
the combination is
ncave lens
[*Ans*—24 cms

Powers of a lens

iprocal of its focal

c sum of the powers

focal length 20 cms
[*Ans*—1/20, 1/10

2 It is placed in
What is the power
[*Ans*—3

Defects of Vision —

An eye is said to be defective or not normal when its *Far Point* is not infinity and its *Near Point* is not at the *Distance of Distinct vision*. It then requires a *lens* for its correction.

A short-sighted or a *Myopic* eye can not see things at a distance. It requires a *Concave* lens of a calculated *power* for its correction.

A long-sighted eye cannot see clearly things at a near distance. For its correction a *convex lens is used*.

EXAMPLES —

86. The distance of most distinct vision for a person is 20 cms. and he uses a reading lens of 4 cms. focal length. Find the magnifying power of the lens. Where must the lens be held in order that he may clearly read a book?

The image ought to be formed at a distance of 20 cms.

Hence $\quad \frac{1}{20} - \frac{1}{u} = \frac{1}{5}$

Whence $u = 4$, *i.e.*, lens must be 4 cms. from the book.

Again $\quad m = \frac{v}{u} = \frac{20}{4} = 5$

87. The nearest distance of distinct vision for a long-sighted person is 50 cms. and he uses convex spectacles of 30 cms. focal length. Find how much will he increase his range of distinct vision?

By using a convex lens objects at a distance u can have their image formed at a distance of 50 cms. from the eye and u is determined by the relation

$$\frac{1}{50} - \frac{1}{u} = -\frac{1}{30} \quad \text{whence } u = 18.75$$

Thus the range is increased through $(50 - 18.75)$ or 31.25 cms.

88. A short-sighted person has distinct vision at 5 in. What kind of a lens should he use and of what focal length to enable him to read a book 20 in. from his eyes.

book, distant 20 in from the eye
ince of 5 in from the eye

$$\text{whence } f = +\frac{20}{3} \text{ in}$$

concave and of focal length $6\frac{2}{3}$ in.

istinct vision for a short sighted
focal length of the lens to be used
early an object 50 cms from his
[*Ans* —21 4 cms

tance of distinct vision for a long-
ivex spectacles of 40 cms focal
ortably see through these spectacles

-est distance of distinct vision with
ns and without the lenses this
age is formed, by the lens of 40
an object, held 30 cms from the

$$\frac{1}{30} = -\frac{1}{40}$$

eing the required distance of dis-

e most clearly at a distance of 4
ng him to see clearly things at a
he focal length of the spectacles
am how they act in this case
[*Ans*—concave , f = 6 in.

CHAPTER V

SOUND

Wave-length of a Note.—

Wave-length of a note can be determined from the formula

$v = n\lambda$ where

v = velocity of wave motion
n = number of vibrations
λ = wave-length

EXAMPLES —

1 Establish the relation between the wave-length and velocity of wave-motion in a free medium

2 What is the wave-length of a note of 400 vibrations a second, when the velocity of propagation is 1000 ft per second?

3 A body vibrating with a frequency of 100 sends waves 10 cm long through a given medium Find the velocity in this medium [*Ans* —1000 cm per sec

4 Longitudinal waves 5 cm long travel through a medium with a velocity of 1100 cm per second Find the frequency of vibration of the body?

We have $v = n\lambda$, here $v = 1100$ cms per sec and $\lambda = 5$ cms
$1100 = 5n$ whence $n = 220$

Velocity of Sound in an Ordinary Gas.—

This has been proved to be given by

$$V = \sqrt{\frac{P \times k}{D}}$$

where V = velocity of sound
P = atmospheric pressure
k = a constant
D = density of the gas

''ı LES —

(lculate the velocity of sound in hydrogen gas, assu- velocity in air, and having also given that 1 litre of weighs 0 0896 gm, and 1 litre of air 1 293 gm

ı n open space *i e* under ordinary atmospheric pressure e velocity of sound in air is given by

$$V_1 = \sqrt{\frac{P \times k}{D_1}}$$

he velocity of sound in any other gas under similar nditions, we have

$$V_2 = \sqrt{\frac{P \times k}{D_2}}$$

$$\frac{V_1}{V_2} = \sqrt{\frac{D_2}{D_1}}$$

ɜre $V_1 = 330\ 6$ and $D_2/D_1 = 0896/1\ 293$

tuting $\frac{330\ 6}{V_2} = \sqrt{\frac{0896}{1\ 239}}$

e $V_2 = 1286$ metres per second

flash of lightning is observed and the thunder is and half a seconds afterwards How far away did cur? [*Ans* —1650 yds

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Velocity of Sound at any Temperature.—

$V = V_0\ (1 + \ 00183\ t)$ where

V_0 = velocity at 0°C

V = velocity at the temp t

average for each centigrade degree rise of temp of sound increases by 61 cms per sec or by about c

ES —

velocity of sound in air at 0°C is 332 metres per the temperature at which the velocity is 340 metres

The velocity of sound at $t°$C is given by

$$V = V_0(1 + 00183\ t)$$

where V_0 = velocity at 0°C

Here $340 = 332(1 + 00183\ t)$

whence $t = 13°$C app

8 A stone is dropped into a well 600 ft deep What time will elapse before the sound of the splash is heard at the top ? Temp of air within the well is 25°C [*Ans* 0 52 secs

9 A person makes a sound by clapping his hand in front of a wall, and hears the echo $\frac{1}{4}$ sec afterwards What is his distance from the wall ? Temp of air is 20°C

The sound first travelled from the person to the wall andl the echo originated at the wall then travelled from th wall to the person, so that it took $\frac{1}{8}$ the sec to trave the distance from the wall to the person

Again velocity of sound at 20°C

$$= 1093 + 2 \times 20 \text{ ft} = 1133 \text{ ft}$$

distance of the wall $= 1133 \times \frac{1}{8} = 141$ ft app

10 An echo repeats four syllables Find the distance of the reflecting surface The velocity of sound is 1120 ft per sec [*Ans* —448ft

11 Two observers are stationed at a distance of $\frac{1}{2}$ a mile and $\frac{1}{4}$ mile respectively from a ringing church-bell Compare the intensities of sound received by the two persons if there is no reflection of the sound in the way [*Ans* —1 4

Beats.—

The number of beats per second between two sounds of *nearly the same* frequency n *and* n_1 is given by

$$m = n - n_1$$

EXAMPLES —

12 The vibration frequencies of two tuning-forks are 340 and 344 Describe what will happen when the two forks are sounded simultaneously How will you find which fork has the higher pitch ?

13 A sonometer string is tuned with a C fork ($n=256$) A fork X produces 5 beats per second with the string A small piece of wax is then attached to one of the prongs of X and the frequency of the beats is increased to 7 per second What is the natural frequency, when unloaded, of the fork ?

The number of beats per sec is equal to the diff in the frequencies of the two forks

This difference is 5 in the first case

Again, since the number of beats is increased when the fork X is loaded with wax, the frequency of the fork is less than that of C

Hence the reqd frequency is $256-5=251$

Frequency of a Note.—

The frequency of a note is the number of vibrations per second executed by the vibrating body

It can be determined by various apparatus e g Savart's Toothed Wheel, Seebeck's Syren, a Sonometer, a Resonant Column of air etc

EXAMPLES ,—

14 Describe some form of Syren Explain how you will use the same to find the frequency of a note from an organ pipe [*Ans* —680

15 If there are 40 holes in the disc of a syren, which revolves at the rate of 1020 per minute, what is the frequncy of the note emitted ?

If there are m holes in a Syren and n revolutions per sec the frequency of the note is given by

$$N=m\ n$$

Here $m=40$ and $n=1020/60=17$

$$N=40\times 17=680$$

16 The disc of a siren contains 32 holes How many revolutions must it take per minute to emit a note which is an octave higher than the middle C ($n=256$) [*Ans* —960

17 A toothed wheel is made to touch a card as it rotates. The note emitted is found to be in unison with a C fork ($n=256$). If the number of teeth be 30 find the speed of the wheel per minute. [*Ans*—512

18 An air-jet is made to play on a ring of 48 equidistant holes in a circular disc that is made to rotate at a constant speed of 10 per second. What is the frequency of the note emitted? [*Ans*—480

Vibration of a string.—

When a string vibrates, its frequency n is given by

$$n=\frac{1}{2l}\sqrt{\frac{T}{m}}$$

where T = tension in absolute units of force (dynes or poundals)

m = mass per unit length of the string

and l = length of the string.

EXAMPLES—

19 Find the pitch of the fundamental note of a string from the following data:—

Length of the string—53 cms.
Mass per cm. length of string—·00323 grams.
Stretching weight—4000 grams.

The frequency n is given by

$$n=\frac{1}{2l}\sqrt{\frac{T}{m}}$$

Here $T=4000\times 981$ dynes, $l=53$ cms. and $m=0.00323$

$$n=\frac{1}{106}\sqrt{\frac{4000\times 981}{.00323}}=329 \text{ approx.}$$

20 A stretched string $4\frac{1}{2}$ ft. long is made to be in unison with a tuning-fork of frequency 287. Calculate the rate of

string when its length is reduced to $3\frac{1}{3}$ ft.
[*Ans*—369

ilar strings are in unison One is 60 cm. by 12 kilogrammes Find

n of the wire, if its length is 45 cm,

;th of the wire when it is stretched by os

gs are in unison, we have

$$n=\frac{1}{2l}\sqrt{\frac{T_1}{m_1}}=\frac{1}{2l_1}\sqrt{\frac{T_2}{m_2}}$$

$_1=m_2$ the strings being similar

$$\frac{\sqrt{12}}{{}^{\prime}0}=\frac{\sqrt{T_2}}{90}$$ Whence $T_2=6\ 75$ kilos,

ond case, we have $l=60$ $T_1=12$ $T_2=20\ 5$

ng in the above formula, $l_1=78\ 5$ cms

hord emits a note of frequency 120 What icy of the note emitted by the same string if eased in the ratio of 4 to 9 and its length in
[*Ans*—150

gives out the note C ($n=256$) when the kg What tension will be required so that it its first lower octave ?

oridge to be placed under the wire so that the s second higher octave ?

$$=\frac{1}{2l}\sqrt{\frac{T}{m}}$$

er octave will have half the frequency of the

$$\cdot 28=\frac{1}{2l}\sqrt{\frac{T}{m}}$$

$28=\sqrt{10}\quad\sqrt{T}$ i e $T=2\ 5$ kilos

d case where the frequency of the second four times that of the given note, we have nce $l'=\frac{1}{4}l$

23 (*a*) A string 50 cms. long, stretched by a weight of 10 kg makes 256 transverse vibrations per second How could the frequency of the note emitted be raised to 384 (1) by altering the length of the string, (2) by altering the stretching weight? [*Ans*,—33 3 cm , 22 5 Kilos

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Organ pipes, Closed and Open —

For a closed pipe to sound its fundamental we have the formula—

$\lambda = 4l$

But $\quad V = n\lambda \quad$ hence $= 4nl$

In the case of the fundamental note of an open pipe

$\lambda = 2l$

Again $\quad V = n\lambda = 2nl$, where

V = velocity of sound
n = frequency of the note
λ = wave-length " "

EXAMPLES —

24 What must be the length of a closed organ pipe which produces the note C ($n = 256$) and that of an open pipe sending the note E ($n = 320$) The velocity of sound is 1152 ft per sec

In the case of a closed pipe

$\lambda = 4l \quad$ and $\quad V = n\lambda = 4nl$

Here $1152 = 4 \times 256 \times l \quad$ whence $l = 1\frac{1}{8}$ ft approx

In the case of a closed pipe

$\lambda = 2l \quad$ and $\quad V = n\lambda = 2nl$

Here $1152 = 2 \times 320 \times l \quad$ whence $l = 1\ 8$ ft

25 The length of a pipe, open at both ends, that is in unison with a certain fork is 2 ft the temperature being 15°C, Find the frequency of the fork [*Ans* —280

26 The sound of an excited fork swells out loudly when held over a gas jar 6 4 in long and of 1 in radius Find the

Calculate also the
20°C
ir and the length of

end correction)

1133 ft per sec
+ 6)/12

λ=28 in app

gives the maximum
6 is held over it
per sec Determine
[Ans —12 in

esonance in a pipe
2 in in diameter
ound in air at the
[Ans —449 ft sec

open organ pipe
e in unison with the
per minute Find

o=560

1120 ft per sec
ence $l=1$ ft

CHAPTER VI

MAGNETISM

Laws of Magnetic Force

Let m and m' be the respective strengths of two magnet poles and d the distance between them Then the force between them is given by

$$F=\frac{mm'}{d^2} \text{ where } F \text{ is measured in dynes}$$

EXAMPLES —

1 The respective strengths of two N-poles are 5 and 10 respectively and they are 10 cms apart Find the force of repulsion between them

Here $m=5$, $m'=10$ and $d=10$

$$F=\frac{5\times 10}{10^2}=0\ 5 \text{ dynes}$$

2 A north pole of strength 4 is placed 5 cms from a south pole of strength 3 Find the nature and magnitude of these forces [*Ans* —Attractive , $F=$ 48 dynes

3 A north pole of strength 5 is placed 20 cms from a south pole and the force exerted between them is 0 25 dynes find the strength of the south pole [*Ans* —5

4 A south pole of strength 5 when placed 25 cms from a north pole attracts the former with a force of 1 dyne Find the strength of the pole [*Ans* —125

5 Two north poles repel one another with a force of 2 4 dynes when their distance apart is 2 cms what will be their distance apart when the force is 3 6 dynes ? Find also the repulsive force when their distance apart is 3 cm

[*Ans*, *Cf* C U 1916

6 A force equal to the weight of four ounces is required to pull a small ball of soft iron from contact with one of the

poles of a magnet A, and a force equal to the weight of nine ounces is required to pull the same ball off one of the poles of a second magnet B Show the relative strengths of the magnets A and B [*Ans.*—2 3

7 A magnet pole of strength 72 attracts another distant 3 cms from it with a force equal to the weight of a gramme What is the pole strength of the latter ? [*Ans* —122 625

Hint Force = wt of 1 gm = 981 dynes

Magnetic intensity of a point.

The intensity of magnetic force at a point is measured by the force exerted on an unit pole placed at the point

8 Find the intensity due to a magnet pole of strength 81 at a point distant 9 cms from it [*Ans* —unit intensity

9 What is the strength of a magnet pole which is urged by a force of 3 dynes when placed in a field of intensity 0 3 [*Ans*—10

10 The length of a magnet is 5 cms and it is placed in a field of intensity $H = 0{\cdot}18$ What is the moment of the couple required to deflect it (1) through an angle of 30° from the magnetic meridian (2) at right angles to the magnetic meridian ? The pole strength of the magnet is 3

Here, force acting on each pole $= 3 \times 0{\cdot}18 = 0{\cdot}54$

(i) The arm of the couple $= 5 \sin 30^\circ = 5/2$

the moment of the couple $= 0{\cdot}54 \times 5/2 = 1{\cdot}35$

(ii) When the needle is at right angles, the arm of the couple = length of the needle

the moment of the couple $= 0{\cdot}54 \times 5 = 2{\cdot}7$

CHAPTER VII.

FRICTIONAL ELECTRICITY

Coulomb's Law.—

$F = \frac{q \times q'}{d^2}$ where

F = force in dynes
q = quantity of electricity in one charge
q' = „ „ „ „ the other „
and d = distance between them

EXAMPLES —

1 Two small insulated metal spheres charged respectively with -5 and 5 units are placed one metre apart What is the direction of the resultant electric forces exerted on a small + charge at a point one metre distant from the centres of each of the spheres ?

Here force due to the charge + 5 on the small charge q say,

placed 1 metre apart $= \frac{5 \times q}{100^2}$

That due to the charge -5 $= \frac{5 \times q}{100^2}$

The former being repulsive and the latter attractive while both are equal in dimension, their resultant is a force paralled to the line joining the centres of the spheres

2 Two small insulated spheres are charged with + 10 and 30 units respectively The distance between the spheres being 5 cms what is the force of attraction between them ?

[*Ans.*—12 dynes-

n between two bodies was 8 dynes
s apart What is the charge on
e the – charge ?

$= 2q'$

id $q' = -12$ units

spheres repel each other when
apart with a force equal to the
hat is the charge on each in elec-

g is equivalent to a force of

$\frac{980}{0 \times 10}$ dynes

$\frac{6 \times 980}{0 \times 10 \times 10}$

(2 4)² app

120 units

10 and 5 units are given to two
e of 50 cms apart At what point
he charges is the electric force zero

d distance from the charge of 5
ance from the charge of 10 units is
ve

$\frac{}{2} = \frac{5}{x^2}$

$2 = 50 - x$ whence $x = 20\ 3$ cms

es of 10 units each are placed on
pposite corners of a square of 10
e electric force at either of the
[*Ans* — 14 dynes.

Electric Potential.

there is a charge q collected at a
of potentials due to it at any two

Elecuical Capacity of a Body—

ıny conductor ıs measured by the quantity d to raıse ıts potentıal from zero to unıty

tıal of a conductor depends both upon ıts nd upon ıts capacıty, ın fact ıf C be the ıctor, Q the quantıty of electrıcıty wıth and V ıts potentıal, then

$$C=\frac{Q}{V} \quad \text{or } Q=CV$$

ıer of conductors of capacıtıes C_1, C_2, C_3, dıstances apart, have potentıals V_1, V_2, hey are joıned together by fine wıres (of acıtıes), theır common potentıal V ıs gıven

$$\frac{V_1+C_2V_2+C_3V_3+\text{ etc}}{C_1+C_2+C_3+\text{etc}}$$

ıantıty of electrıcıty whıch must be gıven re 6 cms ın dıam so that ıts potentıal zero to 15

f the sphere, beıng equal to ıts radıus ıs

ıtity reqd $=3\times 15=45$ unıts

ılated metal spheres at consıderable dıstan- ged wıth electrıcıty tıll theır potentıals are If theır radıı are 2, 3, 4 respectıvely, find whole system when they are connected by

qd potentıal

$$V=\frac{2\times 2+5\times 3+4\times 7}{2+3+4}=5\ 2$$

ı of the spheres were 4, 5 and 6 cms respe- ıtıal potentıals were 6, 7 and 8 respectıvely, f the whole system when joıned by a wıre

[*Ans* —7 13

14 The capacity of three spheres are 3, 2, and 1 respectively and their potentials are 1, 2 and 3 What is the common potential when they are all joined by a very fine wire ?

[*Ans* —1 6

15 Two insulated brass balls are joined by a long fine wire one has a diam of 3 in and the other a diam of 1 in A charge of 48 units of + electricity is given to them How will the charge be distributed ?

Here, the potential of the two balls is the same, hence the charges of the two balls are proportional to their capacities and the capacity of the first ball is 1 5 while that of the second is 0 5 , then the charges are in the proportion 1 5 . 0 5 or 3 1 , *i. e* the charges are 36 and 12 units respectively

16 A charge of 1000 units is given to two insulated balls of capacity 10 and 15 units respectively What is the charge on each ball and the potential of the system ?

[*Ans*—V=15 , charges=1125 &375

17 Two insulated metal balls are connected by a fine wire, one has a radius of 5 cms. and the other a radius of 8 cms They are charged and on testing the larger one, it is found to have a charge of 16 units What was the total charge ?

The charges are in the ratio of their capacities, then we have

$$4 \quad 25=16 \cdot x$$

Or $$x=10$$

total charge $=16+10=26$ units

18 The diameter of a sphere is 5 cms. and it is charged until its surface density is 5/– What is its potential ?

[*Ans* —500

19 Two insulated and widely separated metallic spheres receive charges of positive electricity which raise their potential to 4 and 5 respectively The densities of the charges being in the ratio 4 9, compare the radii of the balls

The densities being in the ratio of 4 : 9 the charges are in the ratio of $(4\pi r^2 \times 4)$ $(4\pi r^2 \times 9)$

Then since $$\frac{Q}{V}=C$$

he respective capaci-

ns radius is brought
is then brought into
he free charge ?

gion of potential 5 it
f + electricity on one
e other side remote
onnected to earth 20
ing 20 units of − re-

ought into a region
inger and then re-
negative electricity
[*Ans* —4 cms

in charging a sphere
ig 4 cms

is raised from 0 to

he work done $= \frac{QV}{2}$

$\frac{V}{2} = 6$

how much work has
rom 0 to 50 ?
[*Ans*,—7500 Esgs

CHAPTER VIII

CURRENT ELECTRICITY

Resistance of a Conductor —

The resistance of a conductor is directly proportional to its length and inversely proportional to the area ot its cross-section

If there are two uniform conductors of length l_1 and l_2 and of the same material, then the ratio of their resistances R_1 and R_2 is

$$\frac{R_1}{R_2}=\frac{l_1/s_1}{l_2/s_2}=\frac{l_1\,s_2}{l_2\,s_1}$$

s_1 and s_2 being the cross-sections of the two conductors

The resistance of a conductor also depends upon the material of which it is made The *Specific Resistance* of a substance is defined as the resistance between opposite faces of a unit cube of the substance

Thus, if a conductor of length l and cross-section s has a specific resistance ρ, then its resistance is $\rho \times l/s$ in C G S units expressed in *ohms* its resistance is $\rho \times l/s \times 109$, for one ohm $=10^9$ G G S units of resistance

EXAMPLES —

1 What is the resistance of a column of mercury 2 metres long and 6 of a sq mm cross-section at $0^\circ C$?

Here length of mercury column is 200 cms and cross-section is $6/10^2$ sq cms , also the specific resistance of mercury is 96×10^{-6} app

Hence resistance of the column $=\dfrac{96\times 10^{-6}\times 200\times 10^2}{6}$

$= 3\ 2$ app.

a diameter of 3 mm
opper wire having a

$\overline{o^2}$ and $\frac{\pi \times (1\ 5)^2}{10^2}$

$\frac{10^2}{\pi}$

es

rrent of o 5 amperes
90 volts, what is its

o ohms

i circuit) of 20 volts,
the *E M. F* falls
isses through Find
the resistance of the

olts,

ire $= E/C = 15/2 = 7\ 5$

ence that causes the
ough a wire of resist-
of the battery being
nal resistance of the

whence $R' = 2\ 5$

ugh a conductor, the
ence of potential of
[*Ans*—2 ohms

is resistance takes a
F, reqd to work it?
[*Ans*—30 ohms

milar wires, one of
[*Ans*—$R = 81 R_1$

are drawn into wire,
ito a wire 20 ft long

If the resistance of the shorter wire is 0·5 ohms what is the resistance of the longer wire ? [*Ans* —2 ohms

Ohm's Law :—

With suitable units Ohm's law may be expressed by means of an equation, thus—

$$C=\frac{E}{R}$$

where C=Current in *amperes*, E=E M F in *volts* and R=resistance in *ohms*

If the whole resistance R, be divided into *r*, the internal resistance of the cell and *R*, the total external resistance of the cell, then—

$$C=\frac{E}{r+nR}$$

Grouping of Cells ,—

(*a*) *In parallel*—In this arrangement with *n* cells Ohm's law becomes—

$$C=\frac{E}{r+Rn}$$

(*b*) *In series*—In this case Ohm's law becomes with *n* cells—

$$C=\frac{E}{nr+R}$$

(*c*) *Mixed circuit*—If we have *n* rows of *m* cells arranged in series then,

$$C=\frac{nmE}{mR+nr}$$

In this case, it may be proved that the current is maximum when $R=\frac{mr}{n}$

EXAMPLES —

9 Five Daniell cells, each having an *E M F* of 1·08 volt, and an internal resistance of 4 ohms are joined in series , what

al resistance of 5

have,

·16 amperes

es, yields a current
is 10 ohms, and a
istance is 20 ohms
a cell [C U 1911

rough a circuit of
the cell producing
[C U. 1914

stance of 0 3 ohms
When the circuit
ms and resistance
l a current passes
l also the current
, P D = 1 44 volts

2 and its resistance
by it when its poles
is 16 (2) by a wire

t is 1·2

res

eres

al resistance 3 and

milar ends of each

nected by a wire of
the current in each

(*a*) This is the case of a group of cells joined in series then

$$C=\frac{nE}{nR'+r}=\frac{10\times4}{10\times3+20}=8 \text{ ampere}$$

(*b*) This is the case of a mixed circuit, then, we have

$$C=\frac{nmE}{mR'+nr} \quad \text{here } m=5 \text{ and } n=2,$$

then $$C=\frac{40}{15+40}=\cdot727 \text{ ampere.}$$

15 Find the best arrangement of 24 cells having an external resistance of 3 ohms and each cell having an internal resistance of 2 ohms

We know that with a *given* external resistance the maximum current with n rows of m cells in series is obtained when $r=\frac{mR'}{n}$ or $nr=mR'$ Thus we have to arrange the cells in such a way that the above condition may be satisfied

Now, we have here $n\times m=24$
and $r=3$ and $R=2$
$3n=2m$ i, e, $m=3/2\ xn$
then $n=4$ and $m=6$

Thus, the arrangement is four rows of six cells in series

Divided Circuits.—

If two points A and B of a circuit be joined by several wires of resistances r_1, r_2, r_3 etc and if R be the equivalent resistance, then

$$\frac{1}{R}=\frac{1}{r_1}+\frac{1}{r_2}+\frac{1}{r_3}+\text{etc}$$

Shunts —

The current C_s passing through the shunt is given by

$$C_s=\frac{G}{S+G}C \quad \text{where}$$

ie total current
esistance of the galvanometer
" " shunt
iometer by

C

ined in parallel, their resistances
e the resistance of the conductor

whence $R = 6\ 6$ ohms
o

ned in simple circuit, their resista-
ims , find the resultant resistance
[*Ans* —12 7 ohms
tween two points A and B of a
lding a wire between A and B the
, what is the resistance of the added
[*Ans* —150 ohms
2000 ohms is shunted with a wire
the resistance of the shunted gal-
[*Ans*— 99 ohms
eres flows through a galvanometer
ith a shunt of 1 ohm resistance
through the galvanometer ?

$\frac{1 \times 4}{00 + 1}$

·19 ampere

40 ohms resistance is shunted by a
resistance of the shunted galvano-
flows through it when a difference
intained between its terminals
[*Ans*—4 5 ohms, 4 amp
consists of two wires of the same
and l', and cross-sections s and s'
currents in the two wires
[*Ans* —$C \quad C' = l's \quad ls'$

Heating effect of a Current—

From Joule's Law we have

$$JH = C^2Rt$$

i.e.

$$H = \frac{C^2Rt}{J}$$

$$= \frac{C^2 \times R \times t \times 10^{-2} \times 10^{9}}{4.2 \times 10^{7}}$$

$$= C^2Rt \times .24 \quad \text{where}$$

J = mechanical equivalent of heat = 4.2×10^7 ergs
R = resistance in ohms = $R \times 10^9$ in absolute units
C = current in amperes = $C \times 10^{-1}$ in absolute units
t = time for which the current flows

EXAMPLES —

23. The *E. M. F.* of a battery is 18 volts and its internal resistance 3 ohms. The difference in potential between its poles, when they are connected by a wire *A*, is 15 volts, and falls to 12 when *A* is replaced by another wire *B*. Compare the amount of heat developed in *A* and *B* in equal times.

Heat developed in both cells in equal times is proportional to $C^2R = EC$.

In the first case, we have

$$C = \frac{15}{R}, \; R \text{ being the resistance of the wire } A$$

and $\quad 18 = C(3 + R)$ whence

$$C = 1 \text{ ampere}$$

Heat produced $= EC = 15$

In the second case, similarly we have,

$$EC = 24$$

their ratio = 15 : 24

24. A current of 1 ampere passes through a coil whose resistance is 2 ohms. What amount of heat is developed in the coil in 5 seconds?

Here $\quad H = C^2Rt \times .24$

$$= 1 \times 1 \times 2 \times 5 \times .24$$

$$= 2.4 \text{ units}$$

›s passes through a wire whose
›onds What amount of heat
[-*Ans* —108 units

Tangent Galvanometer —

he current strength is given by
iere
ter constant

the radius of the coil and n

the no of turns in the coil
legrees on the scale
nponent of the Earth's field

res flows through a tangent gal-
of wire, each of 20 cms dia-
the field due to the circular
lue of H at the place is 0 18,
›dle be deflected ?

ignetic field produced by the
force on a unit pole and this is
ng one tenth of the $C\ G\ S$ unit
ength of the field is

$$\frac{0\ 9}{\cdot} = 283$$

on is given by

$$\frac{2\pi n}{r}\frac{C}{H}$$

$$\frac{\cdot\pi \times 5 \times 0 9}{10 \times 0\ 18} = \frac{283}{0\ 18}$$

1 572 $\theta = 58^\circ$ app

of 10 cms radius each con-
l be exerted by a current of 0 04
strength 10 placed at the cen-
[*Ans* — 0754 dynes

28 A very short magnetic needle is suspended at the centre of a hoop of wire fixed vertically in the magnetic meridian One current passing through the wire causes a permanent deflection of the needle amounting to 30°, another current causes a similar deflection of 45° What are the relative strengths of the two currents,

Here $C_1 : C_2 = \tan 30^\circ : \tan 45^\circ = \sqrt{3} : 1$

29 In a tangent galvanometer a current of strength C causes a deflection of 30°, another of strength C′ causes a deflec of 45° What is the relation of C to C′? [*Ans* —1 : $\sqrt{3}$

30 If an increase of the resistance of a circuit by 10 ohms causes the strength of the current to decrease from 5 to 2, find the total resistance of the cir cuit after the change

Let E be the E M F and x be the resistance of the cir cuit, then we have

(i) $$\frac{E}{x} = 5$$ and

(ii) $$\frac{E}{x+10} = 2$$

whence $x = 6\ 6$ ohms

31 When a coil of wire is connected in circuit with a battery and a tangent galvanometer, the latter shows a deflection of 45° If the wire is replaced by resistances of 24 and 25 ohms in turn, the deflection is 46° in the first case, and 44° in the second Find the resistance of the wire Tan 44° = 966, tan 45° = 1, tan 46° = 1 036

Let r be the resistance of the circuit and R that of the coil of wire

Then we have,

$$C = K \tan 45^\circ = K$$

i e $$\frac{E}{R+r} = K$$

Similarly $$\frac{E}{r+24} = K \times 1\ 036$$

and $$\frac{E}{r+25} = K \times\ 966$$

tangent galvano-
f 40° was obtained
ection of 35° with
nometer and con-
is Find the inter-
, tan 40 = 8391
[*Ans*—1 03 ohms

nes, and the circuit
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ential between the
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vhence E = 8 volts.

hms and E M F
ge arrangement and
i the arms of the
l the current in the

ge is given by

ampere

Electrolysis ;

The weight of ion liberated is given by

$W = zCt$ where

W = weight of ion in gms
C = strength of current in amperes
z = electro-chemical equivalent,
t = time in seconds

EXAMPLES,—

35 How many amperes would deposit 2 gms of copper in 15 minutes the current being supposed constant ?

Here $W = 2$ gms $z = \cdot 0003276$ and $t = 900$ secs

$$C = \frac{2}{\cdot 295} \text{amp}$$

$$= 6 \cdot 78 \text{ amperes}$$

36. How many gms of copper would be deposited by a constant current of 12 amperes acting for one hour ?

[*Ans* —14 15 gm

37 35 36 gms of copper are liberated in 5 hours by a constant current of C amperes Find the value of C

[*Ans* —6 16 amp

48 What would be the strength of a constant current which liberates 50 c c of hydrogen in 5 minutes ? [*Ans* —

39 0 4 gm of metallic copper is deposited in half an hour on the cathode of an electrolytic cell Find the value of the current passing The E C E of copper = 0 000325.

[C U 1909

1 c c of hydrogen weighs ·0000896 gm
50 c c „ „ ·00448 gm

And from the equation $W = Czt$ we have—

$$C = \frac{W}{zt}$$

Whence $$C = \frac{\cdot 00448}{\cdot 0000104 \times 300}$$

$$= 1 \cdot 4 \text{ ampere}$$

nd on connecting
›bserved that 250
de in 15 min 32

Co npaiisen of Resistances

Principle of Wheat-

(See *De's Practical*
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placed its resis-
s were arranged to
resistance ?
Ans —28 1 ohms

nected in parallel
wheatstone bridge
resistances in the
ohms respectively

nen the resistance

And S is obtained from

$$\frac{P}{Q}=\frac{R}{S}$$

or $$S=\frac{Q\ R}{P}=\frac{10\times 12}{30}=4 \text{ ohms}$$

whence $x=20$ ohms

43 An unknown resistance x and a coil of 10 ohms are put on the gaps of a metre bridge and balance is obtained when the jockey stands at 35 cms from the end nearest the unknown resistance Find the unknown resistance

Here $$\frac{10}{x}=\frac{35}{100-35} \quad \text{whence } x=18\ 57 \text{ ohms}$$

44. Two resistances of 10 and 40 ohms are put in the gaps of a metre-bridge, At what position of the key there would be no current in the galvanometer ?

[*Ans* —25 cms from one end

45 An electric current of 5 amperes is divided into 3 branches, the lengths of the wires in the three branches being proportional to 1, 2, 3 , find the current in each (the wires are of the same material and cross-section) [C U 1912

UNIVERSITY PAPERS

WITH

ANSWERS

The Calcutta University
Intermediate Examination
Papers

ON

PHYSICS

FROM 1909 TO '19
WITH ANSWERS

CALCUTTA
CHUCKERVURTTY, CHATTERJEE & Co
15, COLLEGE SQUARE

NOTE

r the convenience of reference the subject matter of each n has been shown on the MARGIN *on the right hand side*

rginal note

In cases where a question has been repeated in the University Papers of different years, r, the paper and the question number of such repetitions so been put in the margin, from which it is hoped, the will be able to realise the importance of a question from iversity stand-point

drawing GRAPHS *students are advised to provide them- vith squared papers of the same size as are often supplied*

n graphs

at the examination hall Such a piece of paper generally contains 8 big divisions on 'e and 10 on the other, each big division containing ler ones It should be remembered that numerical nust be assigned to a division on the squared paper along is, such that the graph when drawn may fairly extend the whole of the squared paper The nature of the graph xt be verified from those that have been inserted in this For directions on drawing graphs in Physics, see De's al Physics, page 19

PHYSICS.

1909

Paper-setters { MR C. W PEAKE, MR R S TRIVEDI, DR E P. HARRISON

FIRST PAPER.

Only SEVEN *questiones to be attempted, of which the tenth must be one All the questiones are of equal value*

1 You are provided with a strip of plane mirror, some pins and drawing materials How would you prove experimentally that the image of a fixed object remains in the same spot whatever may be the position of your eye ? Reflection from Plane Mirror

2 What do you suppose to be the cause of the colour of an opaque object illuminated by white light ? Colour of bodies 11-IA-3

Why do ordinary blue and yellow pigments appear green when mixed ?

Objects which appear variously coloured in white light are illuminated by sodium flame Describe and explain the effect observed

3 Explain by means of diagrams, how the position and size of the image varies with the position of an object for a convex spherical mirror Convex mirror

An object of height 1 inch is placed at a distance of 3 ft in front of a convex mirror of 4 feet radius Find the position and the magnitude of its image

4 A short-sighted man who can read clearly when the print is not more than 3 inches from his eye, requires spectacles to enable him to see a distant view What kind of lens does he need and what must be their focal length ? Draw as accurately as you can, the path of a ray of light from a distant object through the lens of the man's eye (*a*) without the spectacles (*b*) with the spectacles Myopia.

Vapour pressure

5 Two barometers stand side by side A few drops of water are introduced into vacuum of the one and a little air into the other What would be the effects on the errors in the barometer readings thus produced of (*a*) a change in the atmospheric pressure (*b*) a change in the temperature ?

Determination of Pitch 11-I 6 12 I 9 14-I-9

6 Assuming that the velocity of sound in air is known, describe in detail one method of measuring the vibration frequency of a tuning fork

Loudness 12-I-9 Quality Use of Resonance box

7 Describe the physical cause which gives rise to the sensation of loudness and of quality in musical note Why are the strings of such an instrument as the violin mounted upon a hollow wooden box ?

Sp Gr 17-I-3 18-I 3

8 Describe carefully any two methods of finding the specific gravity of a piece of glass

Pendulum

9 Two simple pendulums of length 1 metre and 1 1 metre respectively start swinging together with the same amplitude Find the number of swings that will be executed by the longer pendulum before they are again swinging together [g = 978 cms/sec]

Graph

10 From the following data plot a curve showing the variations in the volume of a mass of water with the temperature Find graphically two temperatures at which the volume of one cubic centimetre of water at 0° becomes equal to 0 99990 c c

Vol of water at diff temp

Temperature	Volume	Temperature	Volume
0	1 000000	7	0 999952
1	0 999948	8	1 000003
2	0 999911	9	1 000068
3	0·999889	10	1 000147
4	0 999883	11	1 000239
5	0 999891	12	1,000344
6	0 999914	13	1 000462

SECOND PAPER 1909

Answer any Two *out of questions 1, 2, and 3, and* Five *from the rest*

1 What do you mean by the term Mechanical Equivalent of Heat?

An engine of 1 horse power is used in boring a block of iron of mass 1000 lb Assuming the whole of the work done by the engine is used up in heating the mass of iron, calculate approximately the rise in the temperature of the iron after the engine has been working for 20 mintues [The number of units of work required to raise the temperature of 1 lb of water 1° Fahr = 772 foot lbs The sp heat of iron = 0 1, 1 horse power = 550 foot lb /sec]

Mech equivalent of heat

2 A small solid metallic object is immersed in a beaker of water and suspended from the arm of a balance What would be the effect on its apparent weight as indicated by the balance of

(*a*) an increase in temperature of the water

(*b*) an increase in the temperature of the solid

(*c*) an equal deerease in the temperature of both water and solid?

Upward press in a liquid

3. What do you mean by the term Latent Heat of Fusion of a substance?

Lt heat of fusion

A lump of ice weighing 100 grammes is placed in a beaker containing a litre of water at a temperature of 52°C When all the ice has melted the temperature of the water in the beaker is observed to fall to 40°C Find the Latent Heat of ice, neglecting loss of heat by radiation and conduction

4 State Faraday's laws of Electrolysis.

Laws of Electrolysis

0 4 gram of metallic copper is deposited in half an hour on the cathode of an electrolytic cell during the passage of a steady electric current. Find the value of the current and name the units

in which you express your result Electrochemical equivalent of copper = 0 000326.

Electromagnetic induction
11 IIB 4
13 II 10
14 II 9

5 Two coaxial cylindrical coils of wire, insulated from one another, are arranged so that the outer one is connected to a galvanometer and the inner one to the terminals of a battery Describe consecutively the behaviour of the galvanometer when the battery circuit is suddenly closed, left closed for two or three minutes, and then opened When the battery circuit is open, describe exactly what is the effect of putting the north pole of a bar magnet into the middle of the inner coil

Illustrate your descriptions by careful diagrams

Metre-bridge

6 Give the theory of Wheatstone's Bridge method of measuring a resistance Draw a diagram of an ordinary metre bridge and show clearly the various connections that have to be made in practice

What is the effect observed if the galvanometer circuit is closed before the battery circuit ?

Heating effect of a current

7 A coil of wire of resistance 2 ohms is soldered to two thick copper rods and immersed in 1000 grams of oil (sp heat of oil 0 6) A current of strength 3 amperes is passed for 30 minutes Neglecting the water-equivalent of the calorimeter, loss of heat by radiation etc, find the rise in temperature of the water A current of 1 ampere passing through a resistence of 1 ohm for 1 sec generates 0 2387 calores

Mag lines of force

8 Describe what is meant by a line of force of a magnet Two bar magnets are placed end to end with the North poles towards one another separated by a few millimetres Draw the lines of force in the plane of the paper, neglecting the effect of the earth's field

What would be the effect on the magnetic field of placing a small ring of soft iron (with its

plane parallel to the plane of the paper) in the space between the two north poles ?

9 The poles of a bar magnet are not necessarily on the axis of symmetry of the magnet How would you find experimentally the direction of its magnetic axis ? Mag axis of a magnet

10 A strip of copper and strip of zinc are dipped into a vessel containing dilute sulphuric acid The strips are attached to the two terminals of a galvanometer, the needle of which is observed to be deflected This deflection decreases considerably after the strips have remained for some time in the acid Why is this ? What methods have been adopted in practice to avoid this effect in voltaic cells ? Give examples Defects of a simple cell and their remedies

ANSWERS.

FIRST PAPER—1909

1 The image of a fixed object in front of a plane mirror seems to be formed at a fixed point behind the mirror, hence from whatever position of the eye it is looked at it remains at the same spot

To locate the position of the image practically, either the *Sighting* method or the *Parallax* method may be adopted (*See D.'-Practical Physics 164*)

2 When white light is incident on an object portion of light is absorbed and is frequently converted into heat second portion is reflected while a third is transmitted The colour of opaque bodies is due to the reflected light while a transparent body has its colour determined by the transmitted light

Thus a body is of red colour because red is the predominant colour in the light reflected from the surface of the body The presence of other colours in the reflected light will determine the so-called shade' of red

Blue pigment absorbs all the components of white light except the blue rays and to some extent their adjacent rays viz, green and indigo Similarly the yellow pigment absorbs all except

ellow and to some extent the green and orange rays Thus a ure of the two appears green, for it is the only portion, that is not rbed by either

Objects appear to be of various colours in the daylight because of seven colours in the white light they absorb nearly all except olours they exhibit

Objects coloured other than yellow in the ordinary day light brought under the yellow light of a sodium flame appear k, because the yellow rays are all absorbed by the body and is no other ray to be either reflected or transmitted by the body h determines the colour of a body, opaque or transparent

() cts coloured yellow, will appear very bright because the yellow are not absorbed but reflected or transmitted, as the case may Bodies coloured green or orange (the adjacent colours to yellow) allow some yellow light to pass through or suffer reflection and e present a slight yellowish tint *(See Glazebrook—Art 125, Ganot—Art 380)*

For a convex mirror the image is always virtual, erect, ller than the object and on the side of the mirror remote from object When the object is at infinity, the image is on the s and is almost a point in size As the object approaches the or, the image moves from the focus to the mirror increasing in from a point to that of the object itself

The following two figures will illustrate the point (Here v a fig after *fig 69 Glazebrook—Light*) Next draw another how the position and size of the image when the object PQ is n nearer Show that the image has grown bigger and has roached the mirror

In the example given, $u=3$ ft $r=-4$ ft., $f=r/2=-2$ ft

Substituting in the usual equation

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$$

We get $\frac{1}{v}+\frac{1}{3}=-\frac{1}{2}$

Whence $v=-6/5$ ft

Thus the image is virtual and is formed behind the mirror

Again the magnitude of the image is given by

$$\frac{\text{Height of image}}{\text{Height of object}}=\frac{v}{u} \qquad \text{or} \qquad \frac{I}{1 \text{ in}}=\frac{6/5}{3}$$

Therefore the image 2/5 in long

4 A short-sighted eye cannot focus for a distant object, in other words, a pencil of parallel rays is made to converge by the human lens at a point not on the retina but a little in front of it,—the lens being too much convergent To focus the parallel rays at a point on the yellow-spot, a divergence should be introduced before the rays pass through the human lens, this can be secured by the use of an auxiliary *concave* lens in front of the human lens

The function of the concave lens will be to produce an image of a very distant object (the rays from which may be considered parallel) at a point 3 in, in front of the eye, so that the eye can then focus for it In other words, the concave lens must have a focal length of 3 in Objects at nearer distances will have their images within 3 in, thus all objects will be seen

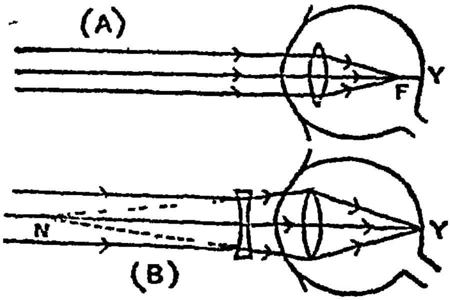


Fig (A) A Myopic Eye without Spectacles
Fig (B) " " with "

Fig (A) shows the path of light from a distant object, passing through the eye without spectacles, fig. (B), with the spectacles on

5 The barometer containing air —

(*a*) Changes in atmospheric pressure will produce smaller variations in the height of a barometric column than in the case of a true barometer, on account of the elasticity of air in the faulty barometer

(*b*) When the temp is diminished, the height of the column will increase as the volume occupied by the air above the mercury level will diminish With rise of temp the gas expands in volume, its pressure also increases and the result is that the column of mercury is forced down

The barometer containing water —Here we have to consider two cases viz,

(1) When the space above the mercury column is unsaturated

(2) When it is saturated with water-vapour

n the first case, it will behave like a gas and the observation be as in the previous case

When the space above is saturated, (a) changes of atmospheric ssure will be correctly shown, since the pressure of aqueous our is constant The pressure of saturated aqueous vapour, ong as temp remains constant, is constant and is obtained from difference in height of the mercury column in the correct baroer and that in the faulty barometer

b) A rise of temp would reduce the mercury column, for, in case pressure of aqueous vapour increases, while, a fall of p would increase the column

) We can determine the frequency n of a fork from the tion

Velocity = frequency × wave-length

To find the wave length in air of the note emitted by the fork arrange to have a resonant column of air corresponding to the

For the practical portion see *De's Sound* *Art* 35, and for the lication of the formula see *Art* 75)

7 For Loudness—*See De's Sound*, *Art* 39 (*i*)

" Quality— " *Arts* 53, 71 first para

The hollow wooden box forms a resonator, the particles of which taking up the vibrations of the string, throw the air-particles within into forced vibrations, thereby increasing the note —*See De's Sound* 39 (*vi*)

8 (*a*) Hydrostatic Balance method, *See De s Gen Physics* *p* 25

(*b*) Nicholson Hydrometer— *See* *Do* *p* 25

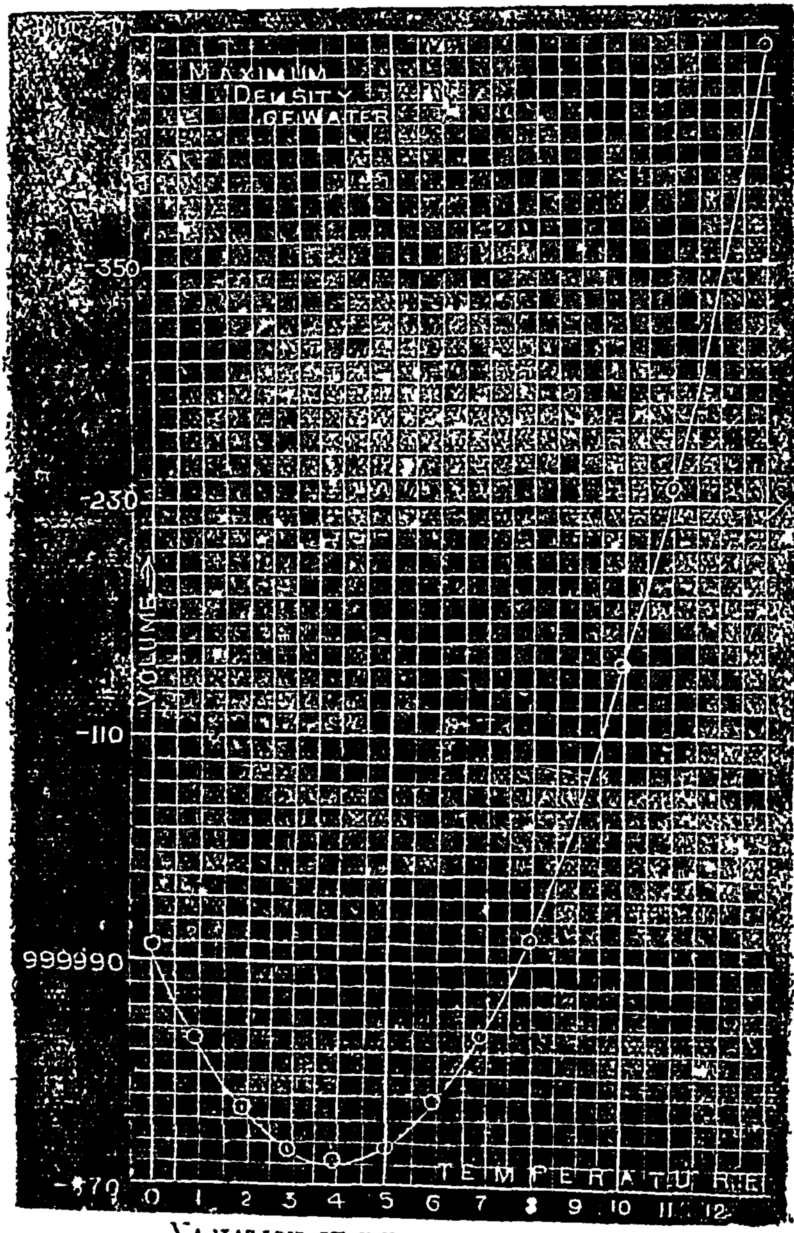
9 The period of oscillation in the case of the shorter pendulum

$$t_1 = 2\pi\sqrt{\frac{100}{g}}.$$

For the longer one

$$t_2 = 2\pi\sqrt{\frac{110}{g}}$$

Let the two pendulums start swinging together Now, when



VARIATION OF DENSITY OF WATER
WITH TEMPERATURE

the longer one has finished the first oscillation, it has taken $t_2 - t_1$ seconds more than the shorter pendulum

Let n be the no of swings of the larger pendulum after which both swing together again When this occurs, $n\ (t_2 - t_1)$ must be equal to t_2 or a multiple of t_2

Let $n\ (t_2 - t_1) = A \times t_2$, where A is any integer

$$\text{Or} \qquad n = \frac{At_2}{(t_2 - t_1)} = A \ \frac{\sqrt{110}}{\sqrt{110} - \sqrt{100}}$$

$$n = A \frac{\sqrt{110}(\sqrt{110} + \sqrt{100})}{10}$$

$$= A \frac{110 + 10\sqrt{110}}{10}$$

$$= A\ (11 + \sqrt{110})$$

$$= A \times 21\ 2 = \frac{106}{5} A$$

Therefore, to get a whole number for the value of n, the least value of A must be 5

N B —This is not a fair question for an I Sc Paper In fact, the closer is the approximation taken in finding the roots of the irrational quantity, the value of n would go higher Strictly speaking, the correct answer would be infinity

10 From the graph in the opposite page the reqd temperatures are $2^0\ 41$ and $5^0\ 4$C when the volume is 0 9999c c

Here y axis respresents the volume in c c

1 big division $= 0\ 000120$, so 1 small div $= 000012$

And x axis represents temperature in centigrades

3 small divisions $= 1^0$C

SECOND PAPER—1909.

1 For the meaning of the term Mechanical Equivalent of Heat see the note on this given in Part 1

In the example given,

Heat generated by the engine in 20 minutes

$= \text{work done by the engine} \times \frac{1}{J}$

$= \frac{550 \times 20 \times 60}{772}$

$= 8547$ units (taking the heat reqd to raise the temp of 1 lb of water through 1° F as the unit of heat)

Now heat generated by the engine

= Heat absorbed by the iron

$= 1000 \times 0.1 \times t$

i.e. $8547 = 100\,t$ whence $t = 85.47$ F

2 From Archimedes' Principle we know that a body immersed in liquid loses a part of its weight equal to the weight of the displaced liquid

(a) When the temp of the water increases, its density decreases, hence the weight of the displaced liquid being less than before the body appears heavier

(b) As the temp of the solid only increases, it expands in volume and displaces more liquid than before, thus appearing lighter

(c) For an equal decrease in temp of both water and the solid, the following changes occur,—(1) the volume of the body diminishes (2) the density of the water increases But as liquid contract more than solids (their co-efficient of expansion or contraction being greater) the weight of a volume of water equal to that of the solid is greater than before and the body thus losing greater weight appears lighter

3 For the Latent Heat of Fusion of a substance—See *Glazebrook Art 112 (4) or note on it given in Part 1*

In the example given

Heat gained by 100 gms of ice in rising from 0°C to 40°C

$= L \times 100 + 100\,(40-0)$

$= 4000 + 100\,L$ units

Again heat given out by 1 litre of water at 52°C in falling to 40°C $= 1000\,(52-40)$

$= 12{,}000$ units

Now Heat given out by water = Heat absorbed by ice

i.e. $12000 = 4000 + 100\,L$ whence $L = 80$ calories

4 For Faradays Laws—The mass of an ion set free by a current passing through an electrolyte is proportional to

(1) the current strength

(2) the time during which the current passes

(3) its electro chemical equivalent See *Poyesr—Advanced Mag. and Elec Page 270*

From Faraday's Laws, we have

$$W = Czt \qquad \text{See } \textit{note on it in Part 1}$$

Here $W = 0\ 4$ gm $z = 0\ 000326$ and $t = 30 \times 60$ seconds

Thus $0\ 4 = C \times 0\ 000326 \times 1800$

whence $C = 68$ ampere

5 For the diagram—See *Poyser Fig 248, page 285*

For the effects of the current and the magnet—See the excellent table given in *Poyser page 286*

6 For the theory of Wheatstone bridge—See *De's Practical Physics Page 272* For the diagram of a metre bridge and its arrangement see *page 274 as above*

If there is inductance in the circuit there will be a sudden big throw of the galvanometer which may disturb the adjustment

7 In the question there is a misprint, read oil for water

Here, we have that a current of 1 amp flowing through a resistance of 1 ohm and acting for one second generates 0 2387 calories

And, we know that H, the heat generated is proportional to C^2

$$\text{Here } H = 3 \times 3 \times 2 \times 30 \times 60 \times 0\ 2387$$
$$= 7733\ 88 \text{ calories}$$

This quantity of heat has been absorbed by 1000 gms of oil of specific heat 0 6 and its rise of temp t is given dy

$$1000 \times 0\ 6 \times t = 7733\ 88$$

whence $t = 12°\ 9$ C

8 See *De's Practical Physics, page 208*

The lines of force will be like those shown in *fig* 26 *Poyser, page 22*

For the effect of a soft iron ring, *See fig* 33, *Poyser*

9 In determining the magnetic axis it is to be remembered that the latter is always parallel to the magnetic meridian and a freely suspended magnet always rests in the magnetic meridian

To find the magnetic axis, fix two pieces of card-board, one on each of the bar-magnet These card-board pieces should have a hole each to which a vertical cross-wire is attached Now let the magnet be freely suspended over the drawing board when it will be found to rest parallel to the magnetic meridian and the cross-wires will seem to coincide when looking through the hole nearest the eye Now fix two pins on the paper so that these two and the cross-wires appear to lie on the same straight line Draw a st line joining the pins Again, turn the magnet upside down aud obtain another straight line in the same way It will be found that these lines intersect, and the line bisecting them will give the magnetic axis of the bar-magnet

10 The current in the cell may stop owing to the following causes

(*a*) Neutralisation of the acid—which may be remedied by replacing the acid

(*b*) By Local Action—which may be remedied by the amalgamation of the zinc plate—See *Poyser page* 190

(*c*) Polarisation— which may be remedied by the following means —

(1) Mechanical—by brushing the plate from time to time and making the surface of the plate rough

(2) Chemical—by using a second liquid in the cell which will oxidise the hydrogen bubbles —See *Poyser, page* 191

(3) Electro-chemical—by using a porous pot within a cell and arranging matters such that some solid metal such as copper shall be deposited on the cathode instead of hydrogen bubbles

1910

FIRST PAPER.

Paper-setters { DR E P HARRISON, MR BRUHL, MR K K BANERJI }

Six questions are to be attempted of which question 10 *must*

g is the e.

1 Describe in detail how you would test by means of pendulum experiments whether the acceleration due to gravity is the same for all substances

2 A prism of cork, 16 cms high, and of square section equal to 2 cms side is cemented to a prism of lead of the same cross section and 1 cm high The composite prism is allowed to float in water How much of it will project above the surface of the water? [Specific gravity of cork, 0 25, specific gravity of lead 11]

n a

3 Define 'intensity of pressure at a point in a fluid Prove that the difference of pressure between the surface of a liquid and a point in the liquid z cms below the surface is given by $p=gdz$, where d is the density of the liquid, and g is the acceleration due to gravity.

An U-tube open at one end and closed at the other is partially filled with mercury (density 13 6) The closed end of the tube contains some air, and the mercury in the open limb stands 30 cms higher than it does in the closed limb Find in C G S units, the intensity of pressure on the air in the closed end of the tube

atl

4 A cylindrical tube made of non-conducting material and closed at both ends contains 500 grams of lead shot which, when the tube is held vertically occupy 6 cms of the tube length The tube is suddenly inverted so that the end originally above is now below,

and the shots fall to the other end of the tube The tube is then again quickly inverted, and this process is repeated 200 times At the end of this process the temperature of the shot is found, by means of a thermometer, to be 1 4°C higher than it was at the beginning of the experiment Find the value of the mechanical equivalent of heat (Specific heat of lead, 03 It is assumed that no heat is lost by radiation and conduction)

5 Describe an experiment which illustrates the refraction of radiant heat Be very careful to explain what you would use as your source of radiant heat and how you detect the refracted beam — *Refraction of Radiant heat*

6 Distinguish carefully between saturated and unsaturated vapours

Into a cylinder exhausted of air and provided with a piston there is introduced just enough water to saturate the space at 20°C Describe what happens under the following conditions — — *Saturated and unsaturated Vapour*

(*a*) The volume of the space is increased by pulling out the piston

(*b*) The volume is diminished by pushing the piston down

(*c*) The volume remaining as at first, the temperature is inceased to 30°C

(*d*) The temperature falls to 10°C

7 Describe some simple form of syren — *Syren*

The disc of a given syren has 32 holes A tuning-fork makes 512 vibrations per second What must be the speed of rotation per minute of the syren disc so that the note emitted by the syren may be in unison with that emitted by the tuning fork ?

8 Explain what you mean by amplitude of vibration, and velocity of propagation, in the case of a longitudinal wave — *Amp of vibration*

When are two vibrating particles said to have the same phase ? — *Phase*

What are stationary waves ? How are stationary waves produced in the case of a 'stopped' organ pipe ? — *Stationary waves*

8

α for glass

9 A long glass tube of uniform capillary bore contains a thread of mercury which at 0° is 1 metre long At 100°C. it is 16 5 mm longer If the average cœfficient of volume expansion of mercury is 000182, what is the cœfficient of linear expansion of glass ?

Graph

Verification of Boyle's Law

10 In an experiment which had the verification of Boyle's law for its object, the following data were obtained —

Pressure in millimetres of mercury —

230 | 410 | 580 | 760 | 850 | 930 | 1010 |,

Volume in cubic centimetres —

167 | 102 | 73 | 55 | 49 2 | 45 | 41 4 |

Draw a curve representing the relation between volume and pressure at the given steady temperature

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SECOND PAPER.

Answer any TWO *out of the first four and* FIVE *from the rest*

Deviation by a prism

1 Explain how by means of pins and a large glass prism, you could obtain the relation between the deviation of a pencil of light and its angle of incidence on the prism face Draw a curve showing the kind of graph you would expect to obtain, and briefly discuss the meaning of the graph

Photometry

2 You are given a drawing board, a sheet of white paper, a lead pencil, and a metre tape Making use of these articles, how would you compare the candle power of two kerosene oil lamps of different patterns ? Supposing that the candle power of the two lamps are found to be 25 and 40 respectively, what were their relative distances from the screen ?

Pure spectrum

11-IIA-4
13-II-2
14-II-4

3 You are asked to produce a pure spectrum of sun light For what apparatus would you ask ? Describe in detail how you would arrange the apparatus ? Suppose that (*a*) a flame of Bunsen burner, coloured by sodium chloride (*b*) a vacuum tube containing hydrogen and made luminous by means of an electric discharge were used instead of the sun as a source of light, describe in general terms the spectra produced

4 Draw figures, approximately to scale showing the path of the light rays and the positions of the images formed when a luminous object (say an arrow) is placed at a distance (*a*) of 1 inch (*b*) of 6 inches from a convex lens of 2 inches focal length — Image by Convex lens

5 State the law of Ohm If you were given a resistance box, a tangent galvanometer and an accumulator cell of small internal resistance, also copper wire etc, how would you test the truth of the above law experimentally? — Ohm's Law II-IIB-3

6 You are given an insulated charged body, A, a hollow insulated conducting body B, and a larger hollow insulated conductor C The vessel B can be placed entirely inside C without touching it. Show how it is possible to give to C any multiple of the charge on A without bringing A into contact with anything — Electro static induction

7 How would you prove the law of inverse squares for magnetic forces, given (*a*) a magnetised rod of steel about a metre long (*b*) a small suspended magnetic needle, (*c*) a measuring rod and (*d*) a stop watch? — Proof of Mag Law of Inverse squares

8 You have at your disposal (*a*) three Daniell's cells, (*b*) a beaker, (*c*) some platinum foil, (*d*) some thin sheet of copper (*e*) a litre of dilute sulphuric acid, (*f*) insulated copper wire, (*g*) clamps &c Draw a diagram showing how you would arrange matters for the purpose of studying the electrolytic effect of the cells, if one, two or all the cells are joined up in series What different results would you obtain in the three cases? — Electrolysis,

9 Describe what you observe when a discharge from an influence machine is passed between two smooth metallic balls placed at varying distances from each other What difference is produecd in the appearance of the spark by placing a capacity in parallel with the spark-gap? State your ideas as to the mechanical process involved in the passage of the spark — Electric discharge as sparks

10 A current is flowing in a straight wire four meters long You are given a magnetised steel needle about one cm long suspended by means of a silk fibre How would you prove experimentally that the strength of the magnetic field due to the current falls off as the distance from the wire increases? — Mag force due to a current

ANSWERS.

FIRST PAPER. 1910

1 The period of oscillation t of a simple pendulum is given by

$$t = 2\pi\sqrt{\frac{l}{g}}$$

where l = length of the pendulum measured from the point of oscillation to the point of suspension (The pt of oscillation is very nearly the centre of gravity of the pend) and g = the acceleration due to gravity

Take spheres of diff substances, say, lead, copper, ivory etc and suspend each in turn by a string so that the length l (which is equal to the length of the string + the radius of the ball) is the same in each case The radius r is obtained from the mean of several measurements of the diameter of the spheres, taken by a slide-calipers

Note the time taken for some 20 oscillations and hence find t, it will be observed that neglecting the resistance of the air the pendulums oscillate in equal times, thus showing that the acceleration due to gravity is the same for all substances at the same place *See De's General Physics, p 144*

2 We know that a body floating in water displaces a quantity of water equal to its own weight

Here volume of the cork $= 2\times2\times16 = 64$ cc

" " lead $= 2\times2\times1 = 4$ cc

wt of cork $= 64\times0{\cdot}25 = 16$ gms

" " lead $= 4\times11 = 44$ gms

Total wt $= 44+16 = 60$ gms

Let h be the length of the composite prism within the water

Then, vol of water displaced $= 2\times2\times h$ cc

wt of displaced water $= 2\times2\times h$ gms

which must be $= 60$ gms

$\therefore$ $2\times2\times h = 60$ gms whence $h = 15$ cms

the length out of water $= (17-15) = 2$ cm

3 Intensity of pressure *at a point* in the fluid is the pressure on unit area round the point, supposing the pressure is uniform on the surface of the fluid

Press at a pt A within the liquid

=Diff of press at the liquid surface and that at A

=press on a unit area round A

=wt of a column of liquid standing on the unit area and reaching the liquid surface

$=mg$ where m is the mass of the liquid

$=vdg$ where v is the vol and d, the density of the liquid

$=gd\varpi$ for $v=\varpi\times 1$

But vol of liquid in the column

=height of the liqnid × its cross-section

Again, press on the surface of the liquid $=\pi$

where π is the atmospheric pressure

∴ Total press at $A=\pi+gd\varpi$

So that the diff in press at $A=gd\varpi$

See De's General Physics Art 124

Draw a fig of the U—tube and show the heads of the liquid columns in it

Press of air in the closed limb

=atmos press + that due to a column of 30 cms mercury.

As the atmos press and g are not given here we may take their normal values, namely, that due to 76 cms of mercury and 981 dynes respectively

Press of air = that due to (76+30) or 106 cms of mercury

$=106\times 13\ 6\times 981$ dynes $=1\ 4+10^{6}$ dynes.

4 Here, mass of lead $=500$ gms

No of times the tube is inverted $=200$

Dist in cms the shot falls $=(l-6)$ cms l being the length of tube

Rise in temp $=1^\circ_{.}4$C

Sp heat of lead $=0\ 03$

The work done by gravity $=200\times 500\times (l-6)$ gm. cms. units

Heat gained by lead $=500 \times 0\ 03 \times 1\ 4$ units

Mech Equivalent, J $=\dfrac{\text{Work done}}{\text{Heat gained}}$

$=\dfrac{200 \times 500 \times (l-6)}{500 \times 0\ 03 \times 1\ 4}$

$=4762 \times (l-6)$ gm cms units

In the example l, the length of the tube is not given Taking the value of $J=4\ 2 \times 10^7$ gm cms units the intended value of l is about 15 cms

5 An excellent answer to the point is given in *Glazebrook, Heat, Art 160 (i) and (ii) Experiment 50 (a) and (b)*

6 For distinction between saturated and unsaturated vapour see *pages 124 and 131-32 Glazebrook, Heat* State the effects or changes of temp and pressure on saturated vapour (*page 124*) and on unsaturated vapour (*pages 131-32 ibid*)

For the second part of the question —

(*a*) The vapour becomes unsaturated, as the volume of the space which is now increased can hold more vapour

(*b*) When the volume is decreased, there is more vapour than would saturate the space, therefore some vapour is condensed

(*c*) The temp having increased the saturation pressure increases but as there is no more liquid to vaporise, the space becomes unsaturated

(*d*) Some vapour is condensed while the space remain saturated with the saturation pressure at 10°C

7 For the figure and description of the syren, see *De's, Sound Art 60*

Now frequency of the fork

= frequency of the note from syren, when in unison

= No of holes in the syren disc × no of revolution per sec

or $512 = 32 \times n$ $\quad n = 16$ times per second

$= 960$ „ minute

8 In the case of a longitudinal wave such as a sound wave the displacements of a particle in the medium through which the wave is passing, take place along the direction of propagation of

the wave In other words, the particle moves to-and-fro about its mean position, its motion being of the type of a Simple Harmonic Motion

The maximum displacement of a vibrating particle on either side of its mean position is called the *amplitude* of vibration

The velocity of propagation of a wave is measured by the distance traversed over by the wave in one second If λ be the wave-length *i e* the space passed over in the time of one period (T) of the vibrating sonorous body, then

$$v=\frac{\lambda}{T}$$

Two particles are said to be in the same phase when they vibrate in exactly the same way *i e* with the same period and amplitude, they pass the *corresponding points* in their paths at the same instant [*See De's, Sound Art* 13 (*b*)]

When a region of a medium is affected simultaneously by two similar waves *i e* of the same period and amplitude, travelling in opposite directions along the same line it is thrown into a state of vibration, known as stationary vibration Places of no motion (*i e* nodes) and those of maximum vibrations (*i e* antinodes) become permanent or stationary in position

The displacement at each point is in a fixed relation with respect to that of any other point Unlike a progressive wave every particle has got to pass through a cycle of displacements Hence in a stationary vibration there is apparently no transmission of vibratory motion from particle to particle

See De's Sound Art 50

In a stopped organ-pipe, the incident wave and its reflection from the closed end interfere with each other and give rise to a stationary undulation The position of nodes and antinodes within the pipe can be experimentally investigated

N B The explanation of the formation of stationary waves is outside the syllabus of the Intermediate Course in Physics hence a detailed answer has not been given.

9 Expansion of 1 metre of 1000 mm in length of mercury for a rise of temp through 100 °C is through 16 5 mm in length

Co-effit, of relative expansion of mercury

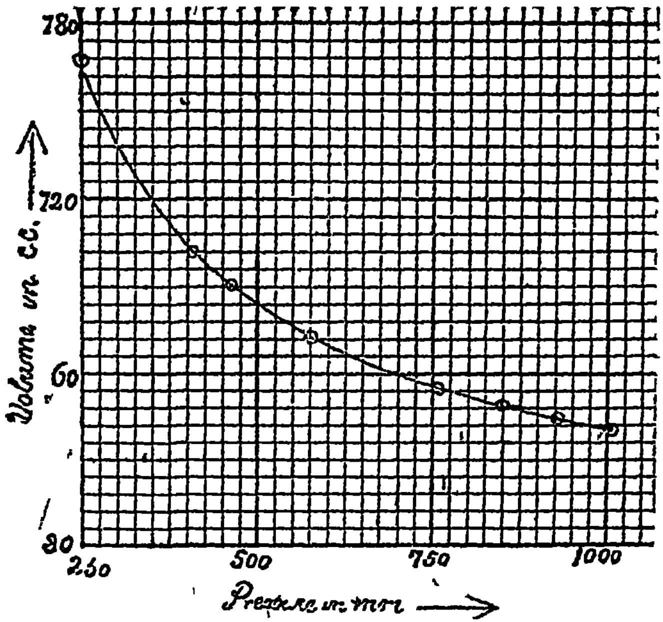
$$=\frac{16\ 5}{1000\times 100}=0\cdot000165$$

But the co-efft of absolute expansion of mercury
$= 0\ 000182$

Therefore co—efft of volume expansion of glass
$= 000182 - 000165 = 000017$

Hence co-efft of linear expansion of glass
$= 000017/3 = 0\ 0000056$ nearly

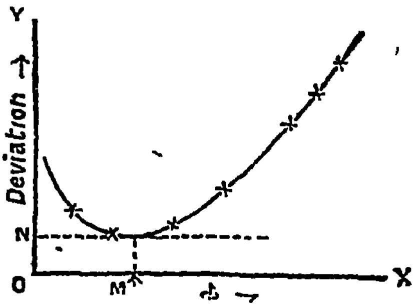
10 In the graph shown below



X axis represents pressure in mm of mercury
1 small div =25 mm
and Y axis represents volume in c c
1 small div =3 c c

SECOND PAPER, 1910

1 For the practical portion see *De, Prac-Physics fig 197* The nature of the graph is shown in the adjoining figure, where Y-axis represents the deviations corresponding to the angles of incidence represented along the X-axis The graph shows that the deviation has a minimum value for a certain angle of incidence marked by an arrow in the figure



For any smaller and larger angle of incidence the deviation will be greater

2 With the apparatus supplied we can arrange a Rumford's Photometer The pencil, held vertically in front of the board on which the sheet of white paper is gummed, can serve for the rod Two shadows of the rod will be cast on the board due to the two lamps in front

Adjust the distances of the lamps so that the two shadows appear to be equally dark, this occurs when the intensity of illumination on the screen due to each luminous source is the same. Next *See De, Prac Physics, Page 156*

In the example, the squares of the distances must be proportional to the candle powers

$$i\ e\ \frac{25}{40} = \frac{d_1^2}{d_2^2}$$

$$\text{or} \quad d_1 \quad d_2 = 5 \quad 6\ 33$$

For production of a pure spectrum see *De, Prac Physics page* 192 For discussion on the purity of the spectrum so obtained, see *Glazebrook-Heat page 186, Art 111.*

For the second part of the question —

(*a*) In this case 'only a bright yellow light is seen' This occurs in the yellow part of the spectrum of white light

(*b*) In this case bright lines, characteristic of Hydrogen are observed Two are very prominent, one occurring in the red part and another in the green part of the solar spectrum A third line, fainter than the other two, is also seen in the blue part of the spectrum

4 (*a*) The case is that of an object lying within the focal gth of a convex lens

Draw a figure after *fig* 95, *Glasebrool*, *Light*, *page* 124, ing AF=2 in and AQ=1 in

The image is virtual, erect and is formed on the same e of the object (*i e*, *v is positive.*)

Show by actual measurtement, from the diagram you have wn, that the image distance=2 in from the lens

(*b*) This is the case of an object lying beyond twice the al length of the lens Draw a figure *after fig* 94, *Glaseok —Light, page* 193
The image is real, inverted and smaller than the object ow from your diagram that the image is formed at a distce —3 in from the lens

5 For Ohm's law, see *Poyser* *Page* 204 Note that the law of m is not only true for the whole circuit but also for a part of the cuit Thus, if *e* represents the difference of potential between two ends of a conductor of resistance *r*, we have $C=e/r$

For the answer to the second part of the question see *De' actical Physics*, *Page* 268, *Method I or II* A diagram of the angement should be given

6 Suppose A has a charge $+q$ Bring B near to A and touch former for a moment, of the charges induced in B, the rt $+q$ passes to the earth and $-q$ remains on it Now bring B ine C and let B and C touch each other, then B is discharged ile the charge $-q$ resides on C By repeating the above process y multiple of the charge on A may be given to C

7 It can be proved theoretically that when a small magnetic edle, suspended horizontally, is made to swing under a magnetic ce,

$$\text{the force} \propto \frac{1}{T^2}$$

ere T is the period of oscillation of the neele

First, let the needle oscillate under the earth's horizontal ld H Observe with a stop-watch the time taken by the edle to complet some 50 oscillations, hence find T, the time one osillation We have

$$H \propto \frac{1}{T^2}$$

Now place the long, magnetised rod of steel to the north of e needle with its axis in line with that of the swinging needle

and with its S-seeking pole pointing towards the needle and at a distance d from it, so that it helps the Earth's field in bringing the needle back to the magnetic meridian, when it is displaced from that position Determine T_1, the new period of oscillation as before We have

$$H+F_1 \propto \frac{1}{T_1^2}$$

Increase the distance d_1 to d_2 and find again the new period of oscillation T_2 We have

$$H+F_2 \propto \frac{1}{T_2^2}$$

From the above, eliminating H, we get

$$\frac{F_1}{F_2}=\left(\frac{1}{T_1^2}-\frac{1}{T^2}\right) \left(\frac{1}{T_2^2}-\frac{1}{T^2}\right)$$

Again, on substituting the numerical value of T, T_1 and T_2 it is found that the right-hand expression is equal to $(d_2/d_1)^2$

$$\frac{F_1}{F_2}=\frac{d_2^2}{d_1^2}$$

In other words, the law of Inverse Squares is true

8 Support by clamps the platinum foil on one side and a thin copper sheet on the other within the beaker Pour a quantity of dilute sulphuric acid in it Connect the sheet by insulated copper wires to the two poles of the battery formed of *two* or *three* Daniell cells in series, the platinum being the anode Draw a diagram (*See fig*, 232 *Poyser*, *Page* 263)

When a current decomposes an electrolyte, it performs a certain quantity of work, this work is expended in decomposing the electrolyte and in opposing the tendency of the liberated ions to recombine

The liberated ions set up a current within the electrolytic cell in a direction opposite to that of the current from the cell It has been calculated that the electro-motive force of this opposing current is 1 49 volts in the case of electrolysis of water which is really the case here

The *E M F* of a Daniell cell is also calculated from the consideration of the energy due to the chemical action going on in the cell, this has been calculated to be 1 129 volts

From the above result we learn that the *E M F* of a single Daniell cell is insufficient to decompose water

In practice, the cell would first send a current through the electrolyte but the current soon drops down and electrolytic action ceases

With two or three cells the electrolytic action would continue to go on, for the $E\ M\ F$ of the electrolysing current is $2 \times 1\ 129$ or $3 \times 1\ 129$ which is higher than $1\ 49$ volts (See *Poyser, page* 226)

N B—This is not a fair question for an Intermediate Paper Further the question is ambiguous

9 When an electric machine is worked, small, straight sparks are seen to pass in quick succession between the discharging balls when these are close to each other As the distance between the balls is increased, the sparks diminish in frequency, become elongated and zig-zag in appearance When the distance is still further increased, the sparks cease to occur altogether

By placing a capacity in parallel with the spark-gap a bigger charge will be necessary for the potential to be raised sufficiently high for the discharge Hence the charge accumulates before the discharge takes place the discharge spark being much more powerful than in an ordinary case

The mechanical process involved in the passage of the spark may be stated thus the tendency of the two opposite charges to recombine increases with their potential difference and when it becomes so great that the air, which is an insulator, can no longer resist their combination, the insulation is broken through and a spark passes which tends to equalise the potential

10 This question is similar to *Q, 7, above,* only the magnetised rod of steel is here substituted for the straight wire, 4 metres long

The wire is placed vertically and the magnetic needle is placed at varying distance d_1, d_2 etc from it on its east side Then as before we have

$$\frac{F_1}{F_2} = \left(\frac{1}{T_1^2} - \frac{1}{T^2}\right) \left(\frac{1}{T^2_2} - \frac{1}{T^2}\right)$$

The right hand side, however, is practically shown to be equal to d_2/d_1

$$\frac{F_1}{F_2} = \frac{d_2}{d_1}$$

i e the strength of the magnetic field due to the current falls off as the distance from the wire increases

1911

FIRST PAPER

Paper setters } DR D N MULLICK, MR C W PEAKE, MR R S TRIVEDI

Only SEVEN *questions are to be attempted*

GROUP A

1 State the principle of conservation of energy and give an illustration — Conservation of Energy 12-I-4 13-I-1

A railway train is moving with uniform speed (*a*) on a level country, (*b*) up-hill Explain how the energy supplied by burning coal in the engine is being expended in the two cases

2 Describe experiments to show that water exerts pressure in all directions — Pressure in a liquid 14-I 2

A plate 10 metres square is placed horizontally 1 metre below the surface of water, when the height of the mercury in barometer is 760 millimetres What will be the total pressure on the plate? (The density of mercury = 13 6)

3 If you were given a piece of wood cut in the form of a cube how would you very roughly determine its specific gravity without using a balance? — Sp Gr without a balance

A Nicholson's hydrometer weighs 200 grammes and requires 50 grammes in the upper pan to sink it to the fixed mark, what weight must be added to or subtracted from the weights in the upper pan to bring it to the fixed mark, when it is placed in a liquid of specific gravity 1 2?

4 State Boyle's law and describe experiments made to verify it — Boyle's Law 13-I-4, 15-I-4

A faulty barometer contains some air which occupies 10 c c If it stands at 740 mm, when a true

barometer indicates a pressure of 750 mm, find the volume, the air will occupy at the standard pressure 760 mm

Graph

5 The mean coefficient of expansion of mercury between 0°C, and t°C is a and the following table gives corresponding values of a and t

t	a
0	0·00018179
100	0 00018216
150	0·00018261
200	0 00018323
250	0 00018403
300	0 00018500

Plot a curve to illustrate the relation between a and t and find from your curve the value of a at 220°C

Pitch by Resonance column 09 I-6 12, I 9 14 I 1

6 Indicate what goes on in the body emitting a musical note and the medium which transmits it

You are given a tall jar, the requisite quantity of water, and a tuning-fork Describe how you will find the vibration frequency of the tuning fork

Group B

7 What do you mean by the specific heat of a substance ?

Sp, ht of a Substance 15-I-6

A lump of platinum weighing one hundred grammes is heated in a flame until its temperature has reached that of the flame It is then removed and dropped quickly in to a calorimeter which has a water equivalent of 5 grammes and contains 495 grammes of water If the temperature of the water rises from 22°C, to 30°C, find the temperature of the flame (The specific heat of platinum is 0365)

Vapour Tension

8 What do you mean by the expression *vapour tension*

Three barometer tubes are filled with mercury and their open ends plunged into a vessel of mercury in the usual way Into the vacuum of one a little air is introduced, and into that of the other a few drops of water What will be the effect in each case on the height of the mercury of plunging the three tubes further into the cistern ? Give reasons for your answer

9 What is the cause of the cooling effect produced

in a room, when a grass (*Khus Khus*) screen moistened with water is placed in front of the door

Steam at 100°C is allowed to pass into a vessel containing 10 grammes of ice and 100 grammes of water at 0°C until all the ice is melted and the temp is raised to 5°C! Neglecting the water equivalent of the vessel and the loss due to radiation, etc, calculate how much steam is condensed (The l tent heat of steam = 536, and the latent heat of water = 80) Lt heat of Steam

SECOND PAPER

Only SEVEN *questions are to be answered which must include either question* 1 *or question* 2 *of Group A and question* 1 *of Group B*

Group A

1 Describe with full experimental details a method of determining the focal length of a convex lens Focal length of a convex lens

Solve the following problem by drawing a diagram to a scale with the help of the squared paper provided An object, 6 centimetres high, is placed at a distance of 40 centimetres from a thin convex lens and an image is formed on the other side of the lens, the height of the image being 4 centimetres Find the focal length of the lens approximately

2 Explain the formation of images by a concave mirror Images by Concave mirror '13 II 3

An object, height 5 centimetres, is placed at a distance of 40 centimetres from the surface of a concave mirror (measured along the axis of the mirror) whose radius of curvature is 20 centimetres Find the position and the size of the image, *without calculation*, as in the preceding problem

3 Why do opapue objects appear coloured? Why does a mixture of ordinary blue and yellow pigment appear green? How would you make a stick of red sealing wax *appear* black? Colour '09 II 2

4 You are given a slit, a convex lens, a screen, and a prism show how you would arrange these to obtain a pure spectrum Explain how it is that the spectrum is not pure when the lens is not used Pure spectrum '10 II 3 '13 II 2 '14 II 4

GROUP B

Electro static Induction

1 A metal globe (insulated) is charged with positive electricity (a) Another insulated metal globe without any charge is placed near it (b) The latter globe is momentarily connected with the earth (c) Both are then enclosed in an insulated case (d) The case is connected to earth Explain what will happen in each case and how you will proced to test your conclusions

Constant Cell
14 II 7

2 Describe any *two* arrangements for maintaining a steady current of electricity in a given wire Explain the two cases What becomes of the energy as it contiues to flow ?

3 State Ohm's Law

Ohm's Law
10 II 5

A battery of ten cells, joined in series, yield a current of 1 ampere when the external resistance is 10 ohms, and a current of 6 ampere when the external resistance is 20 ohms Find the E M F and the internal resistance of one of the cells, (these being the same for all)

Electro Mag Induction
09 II 5
13 II 10
14 II 9

4 You are provided with a suitable voltaic cell, a suitable galvanometer, a soft iron rod, and two pieces of wire, one of considerable length and the other short Exaplain, with the help of a diagram, how you would arrange to demonstrate the production of induced currents

Action of Current on Galv needle

5 A small magnet movable about a vertical axis, is placed at the centre of a circular coil lying in the plane of the magnetic meridian (a) At first no current passes (b) A current is passed, (c) The numbers of turns in the coil is increased, the current being unchanged in strength (d) The coil is slowly rotated about the vertical diameter Explain what happens in all these cases

How to magnetise,
13 II 9
Lines of force of a magnet
14 II 8

6 Describe the various ways of magnetizing a piece of soft iron How would you trace the lines of force in the neighbourhood of a bar-magnet ? Indicate how the shape of the lines you get depends on the earth's magnetism.

ANSWERS.

FIRST PAPER—1911.

1 When energy is lost or expended doing work, an equal amount of energy is gained or produced as the equivalent of the work done Thus a body, or a system of bodies, may lose energy in one form, and gain an equal amount of energy in some other form, or a body, or a system of bodies, may lose energy by doing work on some other body or system of bodies, which thus gains an equal amount of energy as the equivalent of the work done on it

When a quantity of energy is lost or expended in this way in one form, and is gained or produced in some other form, it is said to be *transformed*, or to undergo *transformation*, but whatever the nature of the transformation may be, the quantity of energy produced is always equal to the quantity expended or lost

Thus, when a body falls freely through any distance it loses an amount of gravitational potential energy equal to the work done by the weight of the body during the fall, and gains an amount of kinetic energy also equal to the work done by the weight, that is, the body loses a quantity of gravitational potential energy, and gains an exactly equal quantity of kinetic energy

Similarly, in the case of the bob of a simple pendulum in vibration the bob loses gravitational potential energy, and gains kinetic energy in falling, and it loses kinetic energy and gains gravitational potential energy in rising In moving over any portion of its path, however, the energy lost in one form is exactly equal to the energy gained in the other form each being equal to the work done by or against the weight of the bob The vibration energy of the bob thus remains constant, but is subject to periodic transformation from potential energy to kinetic energy and from kinetic energy to potential energy

In the same way when a body in falling raises another body, the potential energy lost by the falling body is equal to the potential energy gained by the body raised, together with the kinetic energy gained by the two bodies The total energy of the two bodies considered as one system thus remains constant

This is the principle known as the principle of *Conservation of Energy* Maxwell states this principle in the following from ,—

The total energy of any material system can neither be increased nor diminished by any action between the parts of the system, though it may be transformed into any of the forms of which energy is susceptible (*See De's Gen Physics* Art 96)

(*a*) When the train is moving on a level country with uniform speed the energy derived from the burning of the coal in the engine is spent up in overcoming the forces of friction which opposes the motion of the train This energy is equal to the work done by the engine

(*b*) In this case over and above that mentioned in case (*a*) a portion of the energy supplied by the burning coal is expended in taking the train up hill against the attraction due to gravity

2 See De's General Physics Art 124

Pressure per unit area on the plate

=atmos press + press due to 100 cms height of water

=press due to $76 \times 13\ 6$ cms ht of water + that due to 100 cms ht of water

=press due to $(76 \times 13\ 6 + 100)$ or $1133\ 6$ cms ht of water

=weight of $1133\ 6$ c c of water $= 1133\ 6$ gms

And area of the plate $= 10 \times 100 \times 10 \times 100$ sq cms $= 10^6$ sq cms

the total pressure on the plate $= 10^6 \times 1133\ 6$ gms

$= 1133\ 6 \times 981 \times 10^6$ dynes

3 To determine the density of the body very roughly and without using a balance, we may just float the cube of wood in water and measure the part of it that floats out of water

Let l = length of the cube

and l^1 = length of the side of the cube out-side water

The vol of displaced water $= l^2(l - l^1)$ c c ,

wt " " " $= l^2(l - l\ )$ gms , which must be the weight of the cube

$$\text{density of cube} = \frac{\text{its mass}}{\text{its volume}} = \frac{l^2(l - l^1)}{l^3} = \frac{l - l^1}{l}$$

In the example given,—

wt of water displaced $= 200 + 50 = 250$ gms

, ,,' liquid ,, $= 200 + W$ gms, say

But sp gr of liquid $= \dfrac{\text{wt of liquid}}{\text{wt of equal vol of water}}$

Or $1\ 2 = \dfrac{200 + W}{250}$

Whence $W = 100$ gms

Therefore, further wt to be added on the pan $= 50$ gms

4 For the statement and verification of Boyle's Law see *De's General Physics—Art 168*

The example given may be taken in two senses The first one is that the volume of air in the faulty barometer is wanted when the true barometer reads 760 mm In the second one, the vol of the air at a press of 760 mm simply is wanted

In the first case,

Vol of air enclosed in the faulty barometer $= 10$ c c

Its pressure $= (75 - 74)$ or 1 cm height of mercury

When the true barometer reads 76 cms the mercury level in the faulty one will rise, say, through x cms Let α be the cross-section of the faulty barometer tube

Then altered vol of air $= (10 - x\alpha)$ c c

And the new pressure $= \{76 - (74 + x)\} = (2 - x)$ cm height of mercury

Applying Boyles' Law, we get,

$$PV = P'V'$$

or $$10 \times 1 = (2 - x)\,(10 - x\alpha)$$

In this case, no definite solution can be arrived at without the value of α

In the second case,

$P =$ press, due to 1 cm height of mercury

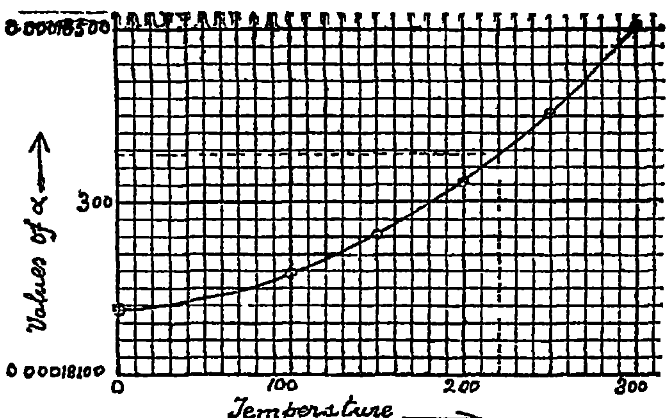
$V = 10$ c c

$P_1 = 76$ cms of mercury

$$V_1 = \frac{PV}{P_1} = \frac{10 \times 1}{76} = 132 \text{ c c approx}$$

5 In the Graph drawn on the other page,

X-axis represents temperature in C
1 small div along it = 10°C
and Y-axis represents co-efft of expansion of mercury
1 small div along it = 0 00000020



The value of α at 200°C from the graph is 0018355

6 A body emitting a musical note is in a state of regular vibration, the vibrations being rapidly executed For a note to be audible its no of vibrations per sec must be between the limits of audibility For the nature of vibrations of sonorous bodies, see *De's Sound Art 5*

In the medium round the vibrating source of sound the vibrations of the body give rise to longitudinal waves consisting of alternate layers of condensation and rarefactions which travel out in all directions See *De—Sound*, *Art 7*

To find the frequency of the given fork proceed as in *art* 35 *De —Sound* and then see *art* 75

7 For specific heat see *Glazebrook, Heat Art 34*

Heat lost by Platinum = mass × sp ht. × fall of temp
$= 100 \times 0\ 0365 \times (t - 30^0)$
t being the temp of the flame
$= 3\ 65 \times (t - 30)$ calories

Heat gained by cal etc $= (495+5)\ (30^0 - 22^0)$
$= 4000$ calories

And Heat lost by Platinum = Heat gained by calorimeter
i e $3\ 65\ (t - 30^0) = 4000$
Whence $t = 1216^0$C app

8 Vapours like gases, exert pressure on all sides of the vessels in which they are contained This pressure is called the vapour tension This is different for different vapours For the same vapour the tension varies with temperature in general For the same temperature the tension of a vapour increases with the quantity of vapour formed but can not be greater than a value which is consant for the temperature This is then known as the saturation pressure of the vapour for that temperature

The behaviour of the three tubes will be as follows —

In the beginning, the height of mercury column in each tube is, of course, such as to indicate the atmospheric pressure Say, it is 76 cm , the space above it being a vacuum

When the first tube, which is allowed to remain a true barometer, is pushed down in o the cistern, mercury column would be unaffected until the top of the tube comes to touch it Then as the tube is further lowered, the mercury column would be obliged to come down, exerting all along an upward pressure against the closed top of the tube, which gradually increases and is always equal to the height of the column in a true barometer minus the reduced height of the mercury column in the tube

In the second tube which contains air above the mercury level, the height to begin with is less than in a true barometer As the tube is lowered the volume of the air diminisnes according to Boyle's Law (*i e* PV=constant, temperature remaining the same), the pressure exerted on the air being always equal to the atmos pressure minus the pressure of the reduced mercury column

As the third tube, in which a few drops of water have been introduced and immediately converted into vapour, is lowered the vapour will behave like the air in the second case so long as it is unsaturated When with the gradual diminution of volume the space containing the vapour becomes saturated, the vapour tension will attain its maximun value at the temperature at the time of the experiment which is constant and may be obtained from the difference of atmospheric pressure and the press of the reduced mercury column in the tube As the tube is still further lowered, water-vapour is condensed, the mercury column remaining at the same height until all the vapour is converted into water After this stage the mercury and water will descend together with the tube, the pressure against the top of the tube increasing as in the first case

9 In evaporation unit mass of water absorbs a quantity of heat (which is called the latent heat of vaporisation) from the surrounding air which thus becomes cooled So to keep a room

cool a *khus khus* screen moistened with water is hung up in front of the door or window

In the example given —

Heat given out by

(1) m gms of steam at 100°C in condensing to water at 100°C $= m \times 536$

(2) m gms of water at 100°C in cooling to 5°C $= m\ (100-5) = m \times 95$

Heat gained by

(1) 10 gms of ice at 0° to melt into 10 gms of water at 0°C$=$ 10×80 1 units

(2) 110 gms of water at 0° to be raised to 5°C $= 110 \times 5$

$$\text{Now heat given out} = \text{heat absorbed}$$
$$(536+95)\ m = 801+550$$
$$\text{or}\quad 631\ m = 1351$$
$$\text{whence}\quad m = 2\ 14 \text{ gms}$$

SECOND PAPER —1911

1 For the experimental determination of the focal length of a convex lens see *Dt'-Prac Physics p 185* (Explain the UV method)

Draw a figure after *fig 94 Glazebrook —Light* where let AQ represent 40 cm Draw PQ = 6 cm Cut off AM from AC such that AM = 4 cm Through M draw MP, a line parallel to the principal axis of the lens

Now draw the central ray PA which we know would pass through the thin lens without being deviated in its course Let this ray meet MP at p Draw pq perp to the axis Evidently pq is the image under the given conditions

Next take a ray from P parallel to the principal axis It meets the lens at R On passing through the lens the ray is deviated to the principal focus F of the lens and will then meet the central ray at p which is the image of the point P So join RP

Then the intersection of Rp and A q is F

Measure AF on the same scale on which AQ = 40 cms and show that AF = 16 cms

2 For the formation of images by concave mirror see text book

thread, share the charge of the proof plane, the pith ball will be repelled when taken near the furthest end of the second globe, thus proving that the charge on this is postive On the other hand it will be attracted by the other end of the second globe, where the induced charge is a negative one

(*b*) On the second globe being momentarily connected with the earth, the induced positive charge escapes to the earth

(*c*) According to the principle of induction, each of the induced charges is equal to the inducing charge, provided the charged body is well within the other, so that all the lines of force starting from the former end at the latter In this case the induced negative charge remaining on the second globe is slightly smaller than the inducing positive charge Thus a few lines of force, may end at the insulated metal base, thus making it slightly negatively charged, if at all, to be tested by putting it in connection with a galvanoscope

(*d*) On the case being connected to the earth leaves of the gold-leaf electroscope will collapse if they had diverged at all in (c)

2 Fully describe a Daniell and a Bunsen cell giving the description of parts and chemical action going on in each cell

The energy is dissipated by the heating of the wire

3 For Ohm's Law See part I *of this book*

In the example given—

If E be the E M F of each cell and r its internal resistance,

$$\text{We have} \quad C = \frac{10\ E}{10r+10}$$

$$\text{also} \quad 0\ 6 = \frac{10\ E}{10r+20}$$

$$\text{Whence } r = 0\ 5 \text{ and } E = 1\ 5 \text{ volts,}$$

4. It is to be assumed that the two pieces of wire given are insulated Wind the shorter piece of wire round the soft iron rod and connect its ends to the terminals of the cell Convert the longer wire into a coil such that the soft iron rod with the coil round may go inside and connect its terminals to the galvanometer Now proceed as in *Poyser, page 285* Sum up your answer by giving the table in *Page 286*

5 (*a*) The magnet will point north and south, lying in magnetic meridian

1912

FIRST PAPER.

Paper setters { Dr D N Mullick, Mr C W Peake, Mr R S Trivedi.

Only—seven *questions are to be attempted All questions are of equal value*

Graph	1 Draw a curve, on the squared paper supplied to indicate the height above ground, at intervals of half a second, of a body falling freely from rest at a height of 150 ft Find from your graph the position of the particle after 1 67 seconds
Laws of Pendulum 13 I 2 15 I-2	2 State the laws of oscillation of a simple pendulum Find the length of a simple seconds pendulum at a place where g is 981 When a ball suspended by a string is made into a 'seconds pendulum,' does the actual length of its string equal the length of the equivalent simple pendulum? If not, why?
Archimedes' Principle 14 I-3	3 State Archimedes' Principle, and explain how it may be used to distinguish a metal from its alloy 1 litre of hydrogen and a litre of air weigh about 0 9 gramme and 1 3 grammes respectively at a certain temperature (t) and pressure (p) What will be the capacity of a balloon weighing 10 kilogrammes, which just floats when filled with hydrogen having the same pressure (p) and the same temperature (t) as the air?
Transformation of energy 11 I 1 13 I 1	4 It is said that most forms of terrestrial energy are derived ultimately from the sun Explain the meaning of the statement, and discuss its truth with special reference to the energy of combustion of charcoal and of coal gas, and the kinetic energy of a running stream
Gas Laws Co effi of exp at constant volume	5 State concisely the relations between the volume, pressure and temperature of a gas Describe an experiment to prove the relation between pressure and temperature when the volume is constant

What volume does a gramme of carbonic acid gas occupy at a temperature 77°C and half the standard pressure? (1 c c of carbonic acid gas weighs 0019 gramme at 0°C and standard pressure)

6 What is meant by the statement that the latent heat of fusion of ice is 80? — Lt Ht of fusion 12-I-5 13-I-5

A litre of hot water is poured into a hole in a block of ice at 0°C, which is immediately closed by a lid of ice After a time the hole is found to contain a litre and a half of ice-cold water What was the original temperature of the water?

7 Discuss as fully as you can the grounds on which we conclude that 'radiant heat' is but 'invisible light — Radiant heat

8 State the law connecting the velocity of sound through a gas with its density Compare the velocities of sound in hydrogen and oxygen under similar conditions Compare further the lengths of two organ pipes filled with these two gases when they give the same musical note (Density of oxygen is sixteen times that of hydrogen) — Vel of Sound in a gas.

9 Distinguish clearly between the loudness and the pitch of a musical note On what physical conditions of the sounding body do they respectively depend? — Loudness 09 I-17 Pitch 14-I 8

A vibrating tuning fork is held near the mouth of a tube closed at one end The tube is found to 'speak' Explain why this happens Assuming the velocity of sound in air to be 320 metres per secoud and the length of the tube to be 32 cm, what will be the time of oscillation of the fork? — Pitch by Resonance. 09 I 6 11-I 6 14-I 9

SECOND PAPER

Only SEVEN *questions are to be attempted All questions are of equal value*

1 State the laws of refraction of light Explain how they are experimentally verified Deduce from these laws the condition of total internal reflection of light Describe some phenomena depending on total reflection — Laws of Refraction 14-II-1 Total int reflection

2. A broad beam of sunlight passes through one face of a glass prism, the prism being held perpendicularly to the beam, and is thrown on a white screen. Describe as accurately as you can, the appearance of the patch of light on the screen and also its movements as the prism is rotated round its axis. Trace the path of any one of the rays incident on the prism.

3. A convex lens of focal length 10 cm. is made to approach a rod of length 5 cm. placed perpendicularly to the axis of the lens. Show by means of typical diagrams drawn to scale (on the squared paper provided), the changes in the nature and the size of the image.

4. Give a brief description of (*a*) the astronomical telescope, and (*b*) a compound microscope, showing by a sketch how the image is formed in each case.

5. Two plates (*A*, *B*) of brass are supported on glass handles and placed facing each other. (*a*) One of the plates (*A*) being connected to a frictional machine and the other (*B*) to a gold leaf electroscope, the machine is worked for some time. (*b*) The plate *A* is disconnected from the machine and (i) it is moved nearer the other, (ii) a plate of glass is interposed between them. (*c*) The plate *A* being disconnected from the machine the plate B is momentarily connected to the earth and then (i) the plate *A* is moved nearer to *B*, (ii) a plate of glass is interposed between them. Explain what happens in each case.

6. Find the electromotive force which will maintain a current of 1.5 amperes through a resistance of 10 ohms.

Mention any three phenomena which are associated with the passage of an electric current, and describe suitable experiments by which they can be shown.

7. A bar magnet is divided in the middle and the parts are separated. An insulated conductor (cylindrical, with the ends rounded off) is placed in front of an electrified ball, with its axis passing through the centre of the ball, and while in presence of the ball the cylinder is divided in the middle and the further half is removed to a great distance. Contrast and explain the state of affairs in the two cases.

8 Describe a simple method of comparing resistances — Comparison of resistances

An electric current of 5 amperes is divided into three branches, the lengths of the wires in the three branches being proportional to 1, 2, 3, find the current in each [The wires are of the same material and cross-section]

9 How would you make an electro-magnet? What kind of material is most suitable for its core? Why? — Electro magnet 15-II 8

An electro-magnet of cylindrical form is placed with its axis (AB) horizontal and perpendicular to the magnetic meridian C is the centre of a small magnet, so that C is in AB produced State what should be the direction of the current in order that the north pole of the needle should be deflected towards the electro-magnet

10 A toothed wheel is capable of rotation about a horizontal axis perpendicular to its plane Describe in detail an electro-magnetic arrangement for producing continuous rotation of the wheel Specify the direction of rotation corresponding to the particular arrangement you propose — Barlow's wheel

ANSWERS.

FIRST PAPER—1912.

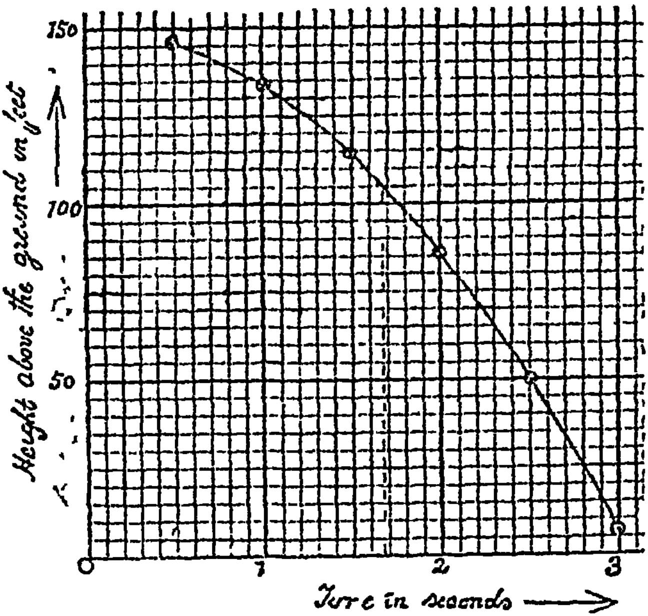
1 The space traversed by a body in time t falling from rest can be obtained from the formula —

$$s = \tfrac{1}{2} gt^2$$

Taking $g = 32$ *ft per sec per sec*, and calculating the distances fallen through at the end of every half second, the following table has been prepared

Time in seconds	1/2	1	1 1/2	2	2 1/2	3
Height fallen through	4	16	36	64	100	144
Height above ground in feet	146	134	114	96	50	6

In the graph
„ 1 small div along X axis = 0 1 sec
„ „ Y „ = 5 ft



In 1 67 seconds, the required height above the ground, from the graph, is 105 ft

2 For the laws of oscillation see *De's Gen Phy Art 86* For the example see *Ex 1 page 1 of this book* The ideal simple pendulum is one in which a mass concentrated at one point is suspended by a weightless string, the length of the pendulum being measured from the point of suspension down to this point In a practical case, as the bob has a certain size, the length of the equivalent simple pendulum is obtained not from the actual length of the string but by measuring the length from the point of suspension to the centre of gravity of the ball, where the whole mass of the ball, may with sufficient accuracy, be supposed to be concentrated Art 140

3 For the statement of Archimedes' principle see *De—Gen Phy Art XX*

A metal can be distinguished from its alloy by applying Archimedes' principle in the following way —

Let the wt of the substance $= w$ gms

Immerse the body in water Let its wt in water $= w_1$ gms

Loss of wt of the body, in water $= (w - w_1)$ gms

Vol of displaced water $= (w - w_1)$ c c

and this must also be the vol of the body

$$\text{density of the body} = \frac{M}{V} = \frac{w}{w - w_1}$$

If the density thus found does not happen to be the same as in the case of a pure metal, it is then an alloy

In the example, the balloon of 10 kg wt is supported by the buoyancy of the hydrogen which is $= 1\ 3 - 0\ 09 = 1{\cdot}21$ gms per litre

$1\ 21 \times$ capacity per litre $= 10$ kg $= 10 \times 1000$ gms

Capacity in litres $= 8264{\cdot}46$

4 Directly or indirectly the sun is the source of nearly all the available energy we possess For our food we are indebted to the sun Vegetable life depends on sunshine Our fuel—coal is due to the sun's action which in past time enabled plants to decompose the carbonic acid of the air and store up the carbon which we use The winds and tides, the rainfall which feeds our rivers and is, the source of our water power, all depend on solar action Life, as we know it, would be impossible without the sun

The energy of charcoal which becomes potent on combustion, is again attributed to the sun Charcoal is, as we see, derived by the incomplete combustion of wood, the water from the latter being driven out Vegetables, again live and grow under the sun, they absorb juices or watery food from the earth and get nourishment from the atmosphere helped by sun's radiation It is the presence of the sun's rays that chlorophyll or the green colouring matter in the leaves of plants can decompose carbon dioxide present in the air and absorb carbon Thus solar energy coming from different sources is stored up as potential energy in a piece of wood which when burnt, liberates this energy in the form of energy of heat accompanied by light energy

Again, the coal gas is a product of incomplete combustion of coal which is raised from mines where wood was converted into coal being subjected to great pressure for thousands of years So the energy of the gas, which can be utilised by burning it, is derived from the stored-up energy of the coal, which, as we have already seen, is derived from the sun

ist quantities of sea-water are being daily evaporated under ction of the sun's rays the vapours so formed, condensing clouds in the higher regions of atmosphere This water down to the earth in the from of rain, which feeds the ig streams, to flow down to the sea, its place of birth nergy of the running stream is thus drived from the poten nergy of the clouds, of which again the source is the nergy (*See General Physic by De Art 95*)

The relation between P and V when T is constant is given yle's Law (See *Gen Physics Art 168*

e relation between V and T, when P is constant, is given by s' Law (see *Text-book*) The two laws are combined in the a,

$$\frac{PV}{T} = \frac{P'V'}{T'} = \text{a constant, say } R,$$

$$\therefore PV = RT$$ *See Glazebrook, Heat page 108*

om the above formula the relation between pressure and ature of a gas when volume remains unaltered, can be d, we have then

$$\frac{P}{T} = \frac{P'}{T'}$$

aries directly as the absolute temperature See *Glazebrook page 104* for the experiment, to be performed with a int Volume Air Thermometer

In the example given,

1 c c of gas at 0°C and 760 mm weighs 0 0019 gm

1 gm of gas occupies $\frac{1}{0\ 0019}$ c c, or 526 3 c c at 0°C and 760 mm

Again we have $\frac{PV}{T} = \frac{P'V'}{T'}$

Here P = 760 mm V = 526 3 c c and T = 273° absolute
and P' = 380 mm T' = 273 + 77 = 350° absolute

Substituting, $\frac{760 \times 526\ 3}{273} = \frac{380 \times V'}{350}$

Whence V' = 1349 5 c c

The statement means that the quantity of heat required

to melt 1 gm of ice at 0°C to 1 gm of water at the same temperature is 80 heat-units *i e* is such as can raise the temperature of 1 gm of water through 80°C or that of 80 gms of water through 0°C This is called latent because its presence within the body is not registered by the rise of mercury level in a thermometer

In the example given,

Heat given out by 1 litre or 1000 gms of water at T°C in falling to 0°C

$$= 1000 \times (T - 0) \text{ calories}$$

This heat is utilised in converting a quantity of ice into half a litre or 500 gms of water *i e* the mass of ice melted is 500 gms

Heat taken up by 500 gms of ice in being converted to water at 0° = 500 × 80 = 40,000 calories

$1000 \times T = 40{,}000$ whence $T = 40°C$

7 Herschel found that as he moved a sensitive thermometer through the solar spectrum from violet to red, it showed only a little rise of temperature in the blue end, a little more in the green a large rise in the red end and even for some distance below the red end *i e* even in the invisible part of the spectrum, the thermometer was sensibly heated Since then it has been known that as glass absorbs a greater part of the *dark heat rays*, a prism of rock salt should be used instead, and the thermometer replaced by a lampblacked thermopile (After this see *Glazebrook, Art 160 Experiment 50 (a)*)

In fact, both heat and light waves are due to vibrations in the ether differing only in frequency or the number of vibrations per second (See the excellent remark on this point in *Glasebrook Light Art 135 para third*)

8 For the first part of the question see *De-Souza Art 18 P 31*

For the latter part of the question suppose l and l_1 are the lengths of the two organ pipes (say closed) filled with hydrogen and oxygen respectively Then from the formula in the case of such a pipe, we have when the pipes are in unison,

$$n = \frac{V}{4l} = \frac{V_1}{4l_1}$$

were V and V_1 are the velocities of sound in the two gases respectively.

$$\frac{l}{l_1} = \frac{V}{V_1} = \frac{\sqrt{d_1}}{\sqrt{d}} = \frac{\sqrt{16}}{1} = 4$$

the hydrogen pipe must be 4 times as long as the other pipe

For loudness and pitch of a note see *De' Sound, Art* 47

The latter part of the question is an instance of Resonance. For explanation see *Art* 74 *De —Sound*

In the example given, we have

$$V = n\lambda \qquad \text{but } l = \lambda/4 \text{ or } \lambda = 4l$$

$$V = 4\,n\,l$$

$$n = \frac{V}{4l}$$

$$= \frac{320 \times 100}{4 \times 32} = 250$$

Time for one complete oscillation $= \frac{1}{250}$ sec $= 0\ 004$ sec.

SECOND PAPER —1912

1 For the laws of refraction see *Glasebrook-Light Art* 33

For experimental verification see *Ganot, Art* 531

Condition of total reflection —If a ray of light passes from a denser medium into a rarer medium, it is bent away from the normal, *i e* the angle of refraction ϕ is greater than the angle of incidence ϕ', such that the refractive index of the denser medium compared to the first is given by

$$\mu = \frac{\operatorname{Sin} \phi'}{\operatorname{Sin} \phi}$$

As ϕ increases ϕ' also increases Let ϕ attain a value θ when the corresponding value of ϕ' is 90^0 *i e*, when the refracted ray just grazes along the surface of the two media Then

$$\mu = \frac{\operatorname{Sin} 90}{\operatorname{Sin} \theta} = \frac{1}{\operatorname{Sin} \theta}$$

For any value of ϕ greater than θ, no refraction is possible The ray suffers total internal reflection retaining the greater part of its intensity. This value of θ is called the critical angle for the media concerned

The mirage is a phenomenon due to total reflection from layers of air For figure and explanation see *Ganot, Art* 356

For other instances see *Glazebrook Arts* 38 (*c*), 40 (*a*) *and* (*b*)

2 An impure spectrum is formed on the screen For its description see *Glazebrook Light Art* 107 *Expt* 16 (*a*)

As the prism is rotated, the spectrum shifts There is a certain position of the prism when the deviation of the bright patch is the minimum See *Art* 107 *Expt* 29 (*b*) *ibid*

To trace the path of a ray see *fig* 122 *ibid*

3 Here f=10 cm Put the object at varying distances from the lens Draw a diagram in each case and tabulate your observations mentioning in each case the value of u taken by you and the corresponding value of v, and the size of the image you actually get

Object Dis — In words	In cms	Pos of Image — In words	In cms	Nature of Image	Size of image	Figure
Beyond $2f$ and at a great dis		bet f and $2f$		Real inverted	Diminished I= cms	See Glazebrook Light fig 94
„ but nearer		„		„	Increases in size	„
At $2f$		at --$2f$		„	Equal in size I= cms	—
Greater than f but less „ $2f$		beyond - $2f$	...	„	Larger I= cms	ibid fig 93
At F	10	at ∞	-	„	Very large	—
Bet F and Lens		beyondF		virtual erect	Larger I= cms	ibid fig 92

4 For description of astronomical telescope—See *Glazebrook Light, Art,* 98

For that of compound microscope See *Art* 101 *ibid* You are to draw a diagram in each case

5 First draw a diagram

(*a*) A becomes charged say, with +ve elect This will induce and attract-charge on the side of B nearest to it, while the induced free charge will be repelled on the furthest end of B and will diverge the leaves of the electroscope

(*b*) (i) As A is made to approach B, there will be greater induction between A and C, as some more of the lines of force from A would now turn towards B, and there will be greater divergence of the leaves connected with B

(ii) As glass is interposed between the two plates, the intensity of the field decreases due to a less number of lines of force passing through from A to B and the divergence of the leaves diminishes

(*c*) The leaves collapse, the free charge on B passing to the earth

6 We have from Ohm's Law

$$E=CR=1\ 5\times 10=15 \text{ volts}$$

For the second part of the question —

The three important phenomena associated with the passage of an electric current are due to its

(1) Heating effect—see *Poyser Experiments 141-43*
(2) Electrolytic effect—see " " *176*
(3) Magnetic effect —see " " *144*

7 A bar-magnet has a N-seeking pole at one end and S-seeking one at the other When it is divided in the middle, the broken ends show polarities such that each broken piece is again a complete magnet with two poles Thus an isolated magnetic pole can never be obtained in practice (*See Poyser, Experiment 12, page 7*)

The charge on the ball induces and attracts a charge of the opposite kind to the end of the cylinder nearest to it, while induced charge of the same kind is repelled to the other end of the cylinder When the two parts of the cylinder are separated, each part contains either all the induced positive or all the induced negative charge, further, as all points on the surface are at the same potential, there would be no flow of charge at the time of separation

8 See *De' Practical Physics page 270*, Wheatstone bridge method of comparing resistances Or if a voltmeter to measure E M F is available, put all the resistances in series with a battery, the same current will, of course, pass through every part of the

circuit As Ohm's Law, $C=E/R$ is not only true for the whole circuit but for a part of the circuit as, we have

$$C=\frac{E_1}{R_1}=\frac{E_2}{R_2}=\frac{E_3}{R_3}$$

where E_1 E_2, E_3 etc are the diff of potentials between the terminals of the given wires respectively, measured by the voltmeter and R_1, R_2, R_3 etc, are their resistances

Hence R_1 R_2 R_3 etc $=E_1$ E_2 E_3 etc,

The second part of the question is an example of divided circuit

Let E be the P D bet the two points when the resistances R_1 R_2, R_3 are joined in multiple arc Let C_1, C_2, C_3 be the currents in the three branches and C the total current=5 amperes

$$\text{We have } E=C_1 R_1=C_2 R_2=C_3 R_3$$

$$\text{Whence } C_2=C_1\frac{R_1}{R_2}=C_1\times\tfrac{1}{2}\text{, and } C_3=C_1\frac{R_1}{R_3}=C_1\times\tfrac{1}{3}$$

$$C=C_1+C_2+C_3=C_1\times\tfrac{11}{6}=5\text{ amperes}$$

$$\text{Hence } C_1=\tfrac{30}{11}\text{ amp}\quad C_2=\tfrac{15}{11}\text{ amp}\quad\text{and } C_3=\tfrac{10}{11}\text{ amp}$$

9 Coil an insulated copper wire so as to make a helix round a bar of soft iron When a current is allowed to flow through the coil, the bar becomes strongly magnetised, the combination being called an electro-magnet

Soft iron is the most suitable material to serve as a *core* for an electro-magnet, as it possesses a great susceptibility and a small retentivity, in other words, as soon as the current is turned up it immediately turns into a powerful magnet and becomes demagnetised just as the current is stopped This is a neccessity for the working of many instruments, such as Electric bells, Telegraph transmitters, Ruhmkorff's coil etc

In the second part of the question, the end of the electro-magnet nearest to the needle must attract the north pole of the compass needle This happens when the current will seem to flow clock-wise in the coil when looked at from the side of the needle

10 The case is one of Barlow's Wheel, For description and diagram see *Poyser page 242, fig 215 and Ganot page 663*

The direction of rotation depends upon that of the lines of force in the field and the direction of the current

1913

FIRST PAPER

Paper setters } DR J C BOSE, MR D N MULLICK, MR R S TRIVEDI

Only SEVEN *questions are to be attempted All questions are of equal value*

Conservation of Energy 11-I 1 12-l 4

1 State the principle of the conservation of energy Illustrate the principle by taking some simple examples

Laws of Pend 12 l-2 15 l 2

2 State the laws of oscillation of a simple pendulum Deduce the effect of temperature on the period of oscillation of a compound pendulum

3 How would you determine the specific gravity of a solid ?

Sp Gr of a Solid 09 l-8 15-l 3

A cubical block of wood of specific gravity of 0'7 floats in water, just completely immersed, when a body of unknown weight is placed on it Find the weight of this body, if the volume of the block of wood is 100 c c

Boyle's Law 11-l-4 15 l 1

4 State Boyle's law Describe a method, of verifying it experimentally

What volume does a gramme of hydrogen occupy at 0°C, when the height of the mercurial barometer is 750 millimetres ? [1 c c of hydrogen weighs 0 0008958 grammes at 0°C and 760 millimetres]

Lt heat 09-II-3 12-l 5

5 Explain the meaning of latent heat How would you determine the latent heat of fusion of ice ?

Explain the cooling effect of a fan

To find α 14 l-7

6 Describe an experiment to determine the co efficient of linear expansion of a metal rod

A copper rod is found to be 5 0009 5 0018 5 0027 metres long at temperatures 10°C, 20°C and 30°C respectively Find, by means of a graph, its length at 0°C Determine also the coefficient of expansion

7 Explain how a knowledge of the boiling point of water would enable us to determine the barometer pressure — Barom press from boiling point

Into the Torricellian vacuum of a barometer water is introduced drop by drop till some water is left over From the depression of the mercury column it is possible to determine the temperature of the room How?

8 Describe a method of determining the vibration frequency of a tuning-fork — Pitch of a fork 15-I-8

If the frequency of a tuning-fork is 400 and the velocity of sound in air is 320 metres per second, find how far sound travels while the fork executes 30 vibrations

9 A sonometer string is stretched with a force of 200 grammes weight (*a*) The force is increased to 800 grammes (*b*) The length of the string is halved How is the pitch of the note emitted by the string affected in each case? — Vibration of string.

SECOND PAPER.

Only SEVEN *questions are to be attempted All are of equal value.*

1 State the laws of reflection of light How would you verify them experimentally? — Laws of Reflection 15 II-1

PQ is an incident ray at a plane surface. If *Q′* is any point on the reflecting plane, show that $PQ+QR$ is less than $PQ'+Q'R$

2 Describe an arrangement of apparatus by which a solar spectrum may be projected on the screen Describe such a spectrum, and give a general explanation of the dark lines in the spectrum — Pure spectrum 10-II-3 11-IIA-4 14-II-4

3 A concave mirror of focal length 8 cm is made to approach a rod of length 4 cm placed perpendicularly to the axis of the mirror Show, by means of typical diagrams on the squared paper provided, the changes in the nature and size of the image — Images by Concave mirror 11-IIA-2

4 Explain how a single convex lens may be used as a magnifier Trace the path of the rays by which an object would be seen in such a case

5 Explain the use of a gold leaf electroscope How would you charge it by induction ?

An electrified ball is made to approach an uncharged gold-leaf electroscope till it touches the electroscope Describe and explain the effects observed

6 Explain the action of (*a*) an electrophorus, (*b*) a condensing electroscope, and (*c*) a Leyden jar In charging a Leyden jar the outer coating is (*a*) insulated (*b*) connected to earth What difference does it make ?

7 Mention any three phenomena associated with the passage of (*a*) 'frictional', (*b*) 'voltaic' electricity Describe suitable experiments by which they can be demonstrated

8 Describe and explain the action of a simple form of tangent galvanometer

With a single Leclanche's cell and a given circuit of a total resistance (including that of the cell and galvanometer) of 10 ohms I get a certain deflection in the galvanometer When the cell is changed, as well as the resistance of the circuit, so that the deflection is again the same, it is found that the total resistance of the circuit (in the second experiment) is 15 ohms Compare the electromotive forces of the two cells

9 What is magnetic induction? How would you distinguish between a permanent magnet and a magnetic substance?

Describe as many methods as you can of magnetising a piece of soft iron

10 Give a brief account of the principal phenomena of electro-magnetic induction, illustrated by typical experiments

ANSWERS.

FIRST PAPER—1913

1 See *the answer to Q 1—I—1911*

2 For the four laws of oscillation, see *Text-book*

The period of oscillation of a pendulum at a temp t is given by

$$T = 2\pi\sqrt{\frac{l}{g}} = 2\pi\sqrt{\frac{l_0(1+\alpha t)}{g}}$$

where l_0 is the length of the pendulum at 0^0C and α is the linear co-eff of expansion of the pendulum rod

$$\text{At } 0^0\text{C}, T_0 = 2\pi\sqrt{\frac{l_0}{g}}$$

$$T = T_0\sqrt{(1+t\alpha)}$$

Hence the period increaes for a rise of temperature Thus, when temperature increases, a clock loses and *vice versa*

3 See *Text Book*

Let the wt of the body $= w$ gms

and the wt of the block $= 100 \times 0\,7 = 70$ gms

According to the condition of floatation,

weight of block + that of the body on it

= upward press due to water displaced by the block

= wt of 100 c c of water

or $70 - w = 100$ gms whence $w = 30$ gms

4 0 0008958 gm of Hydrogen at N T P occupies 1 c c

Substituting $760 \times \frac{1}{0\,0008958} = 750 \times V_1$

Whence $V_1 = 1131$ c c nearly.

5 For the meaning of Latent heat see *De' Pratical Physics p 139.*

For the determination of Latent Heat, see *page 160 ibid*

A fan is able to produce a cooling effect in two ways (1) by accelerating evaporation from a wet surface (2) by promoting ventilation by the speedy removal of hot air and thus producing a breeze of fresh cold air

6 For an experiment to determine α of a metal rob, see *Glazebrook, Art 56*

Let the X axis on a squared paper represent temp. starting from the zero degree, and the Y-axis, the length in metres

Plot the given points and connect them The graph will be a straight line Produce the straight line to meet the Y-axis Then the ordinate enclosed between this point and the X axis gives the length at o C It will be seen from the graph that this is 5 metres

Hence α is given by

$$\alpha = \frac{\text{Change in length}}{\text{length at } 0^{\circ}\text{C} \times \text{rise of temp}}$$

$$= \frac{5\ 009-5}{5\times 10} = 0\ 00018$$

7 We know that water, in fact any liquid, boils at a temperature at which the pressure of its vapour is equal to the superincumbent pressure So noting the temperature of boiling water at any place we are to consult Regnault's Table of pressure of aqueous vapour The pressure at the observed temperature is the required atmospheric pressure

As water is introduced drop by drop into the Torricellian vacuum, more and more water vapour will be formed and the mercury level will go down more and more when the space will be saturated with the vapour and the process of vaporisation will stop The pressure of the aqueous vapour has now been the maximum pressure at the temp of the room, which is constant and is measured by the depression of the mercury column Hence, consulting again the above mentioned table we get the room temperature

8 For the method to determine the frequencies of fork see *De' Sound-Chap X* Any method may be given,—preferably that of resonant column of air See *Arts 56* and *75*

For the example given,

In the time of 400 vibrations of the fork *i e* in one sec, sound travels 320 metres

Hence in the time of 30 vibrations of the fork viz in 30/400 sec, sound will travel $\frac{30}{400} \times 320 = 24$ metres

9 Let n be the frequency of the note emitted by the string when the stretching force T=wt of 200 gms

Now in the case of transverse vibration of a string the expression for n is

$$n = \frac{1}{2l}\sqrt{\frac{T}{m}} \quad \text{where}$$

l = length of string
T = tension of string in dynes
m = mass in gms per unit length of string

(*a*) In the formula given above let T=800 gms and n=pitch

$$\frac{n_1}{n} = \sqrt{\frac{T_1}{T}} = \sqrt{\frac{800}{200}} = 2$$

(*b*) Let n_2 be the pitch of the note when the length is halved Then,

$$\frac{n_2}{n} = \frac{1/\frac{1}{2}l}{1/l} = 2$$

So frequency is again doubled *i e* the first higher octave is heard

SECOND PAPER,—1913

1 For the laws of reflection of light see *Glasebrook, Light Arts*, 23 and 20 or *Ganot Art*, 332

The latter part of the question is on the principle of Least Path in the case of reflection Draw a figure

Draw PNP′ normal to the mirror, and produce RQ to meet PP′ at P′ Join PQ′

Then, since PN=P′N, we have by geometry, PQ=P′Q and PQ′=P′Q′

But P′Q′+Q′R > P′R

i e > PQ+QR

For the production of a solar spectrum, see *Glazebrook, Lt Art, 107 Expt 29 (b)*

The sun is assumed to consist of an incandescent solid or d nucleus, surrounded by a comparatively cooler envelope in h oxygen, hydrogen, iron, calcium etc, are present in the of gases or vapours Now, the vapour of an element rbs the waves which it would itself emit if it were incandescent white light, emitted by the solar nucleus which consists of nous vibrations of all frequencies, is robbed, in passing through solar atmosphere, of those waves which vibrate in the same ds as the elements there present (See *Glazebrook, Light 121*)

Proceed just in the same way as shown in *Q 2—II—1911* take $f=8$ cms and $O=4$ cms here

um up your observations in a tabular form (also shown), in the values of v and I in cms corresponding to the values taken in cms, should be put

A convex lens is used as a magnifier when the object looked within the focal length of the lens A virtual, erect and mag- image appears to be formed on the same side as the object the fig see *fig 92 Glazebrook, Light*

See *De Prac Physics, page 229*

There will be induction on the electroscope due to the presence e charged body, the leaves diver ging with the induced charge e same kind while the induced charge of the opposite kind acted to the top

, the charged ball approaches the electroscope, induction is er and consequently the divergence of the leaves increases

When the ball is made to touch the electroscope the inducing e is neutralised by the induced charge of the opposite kind e top of the electroscope, while the induced charge of the same on the leaves spreads over the conducting part of the electros- and the surfaces of the balls which are now in contact with other In fact, the case has now become a case of conduction, he divergence of the leaves is consequently noticed to ish

(a) See *Poyser, page 89*

(b) „ „ „ *134*

(c) „ „ „ *122*

When the Leyden jar is charged with the outer coating ed, the potential of the latter is very nearly equal but slight-

ly smaller than that of the inner coating, so from the formula $Q = CV$ where V is the diff of pot between the two plates, Q, the charge imparted to the Leyden jar will be small, for the capacity C is constant, depending on the size of the coating and the distances between them

(*b*) When the outer coating is earth-connected its potential falls to zero, hence the diff of pot between the two coatings increases, therefore the quantity of charge the Leyden jar can receive is much greater

7 Frictional electricity does easily give rise to big sparks by means of which a flame can be lighted or gun-powder burnt The mechanical effect of the discharge from a Leyden jar can be demonstrated by letting the discharge pass through a thin glass plate when the latter is pierced through Again, the physiological effect is well demonstrated by the shock experienced when the discharge from a Leyden jar takes place through the body (See *Poyser*, *page 132 Expts 98 and 99*)

(*b*) For the phenomena associated with the passage of voltaic electricity, see the answer to *Q 6—II—1912*

8 For the description of Tangent Galvanometer see *De' Prac Physics, page 249* and for the action and formula, see *Poyser pages 245-47*

In the example given,

In the first case—

$$C = \frac{E_1}{10} \text{ where } E_1 \text{ is the } e\ m\ f \text{ of the 1st cell}$$

In the second case—

$$C = \frac{E_2}{15} \text{ where } E_2 \quad ,, \quad ,, \quad \text{2nd cell}$$

since the deflection is the same in both cases

Therefore $E_1 : E_2 = 10 : 15 = 2 : 3$

9 For magnetic induction, see *Poyser*, *page 11*

A magnetic substance is one which can be acted upon by a magnet and is attracted by either pole of a magnet But a permanent magnet has got fixed polarities and can be attracted by one pole and repelled by the other pole of a known magnet when the latter is presented to the same end of the former,

For the methods of magnetisation see *Poyser, page 15*

10 See *Poyser page 285-86*. Sum up your conclusion dy abing the table given there

FIRST PAPER

Paper-setters { DR D N MULLICK, MR C W PEAKE, MR R S TRIVEDI }

Only SEVEN *questions are to be attempted All questions are equal value*

1 Describe a spring-balance

A set of observations taken with a spring balance is given thus

Weights in the pans (in grammes)

10	20	30	40	50	60	70	90

Extension (in millimetres)

6	13	20	24 5	30 5	38 5	42 2	55

By means of a graph, find the (approximate) relation between these quantities Find the magnitude of the weight that will extend the above spring by 40 mm

2 How would you prove experimentally that a liquid exerts pressure in all directions

A tall vessel provided with a tap at the side, near the bottom is filled with water and made to float upright on a thick plate of cork Expain what will happen when the top is opened

3 State Archimedes' principle How would you verify it experimentally ?

A piece of metal of specific gravity 8 9 weighs 15 8 grammes in water Find its value

4 Explain the meaning of evaporation and ebullition Describe suitable experiments to illustrate their meaning

A flask is half filled with water and heated till the water boils After a short time, when the upper part of the flask is filled with steam, it is well corked and inverted Cold water is now poured over the flask What will happen ? Why ?

5 Explain how you are able to determine (approximately) the height of a mountain, by finding the boiling points of water at its top and bottom

6 Explain how the specific heat of a solid may be determined by means of the ice calorimeter — Sp ht by ice calorimeter

A mass of 500 grammes of copper is heated in an oil bath and then placed in an ice-calorimter If 150 grammes of ice are found to be melted, find the temperature of the oil bath [Specific heat of copper =0 0933]

7 Define the coefficients of linear and cubical expansion — Lin. Co-ff of exp 15-I-14.

A bar 50 cm long is heated from 14°C to 98°C of the increase in length is 0 7 mm, find the coefficient of linear expansion

8 What do you understand by the pitch of a musical note? — Pitch 12-I-9

Two organ pipes of the same length are given, one open, the other closed What should be the relation between the pitch of the fundamental notes emitted by them? — Organ pipes

9 You are provided with a vessel containing water, a glass tube about 40 cm long, open at both ends, and, a tuning-fork whose frequency is 256 Explain how, with these, you would determine the velocity of sound What experimental result do you expect? [The velocity of sound in air is 33280 cm per second nearly] — Vel of Sound by Resonance 09-I-6 11-I-6 12-I-9

SECOND PAPER

Only SEVEN *questions are to be attempted, all of which are of equal value*

1 State the laws of refraction of light Explain how they may be experimentally verified — Laws of Refraction 12-II-1

A coin placed in a basin is hidden from view by the side of the vessel When water is poured into the vessel, the coin just comes into view Explain the phenomenon by means of a diagram

2 Show how to find by a geometrical construction the position of an image formed by a (thin) double convex lens — Images by Convex lens 15-II-2

Find the size of the image on the squared paper provided, the size of the object (placed symmetrically with its centre on the axis) being 5 cm and its distance 30 cm from the lens [The focal length of the lens = 10 cm]

lescope
ll-4

3 Trace the path of the rays in a simple telescope focussed for a very distant object, the object glass and the eye-piece each consisting of a single thin double convex lens

re
ectrum
ll A 4
ll-3
ll-2

4 Light from an illuminated slit is brought to a focus on a screen, after being passed through a double convex lens A prism is then placed between the lens and the screen What will be the effect? Trace the path of the rays

arging a
yden jar
ll-6
ctrostatic
chine
ll 6

5 How would you charge (*a*) an insulated metallic conductor, (*b*) a Leyden jar by induction? Describe a simple form of electrical machine for producing 'static' electricity

pail
ot
l 5

6 On an insulating stand is placed a metal can, the outside of which is connected to a gold-leaf electroscope

A charged metal ball hanging by a silk thread is gradually let down into the vessel, till it rests on the bottom Describe and explain the effects produced

nstant
lB 6

7 Describe a constant cell (any form)

A current of 0 2 ampere passes through a circuit of resistance 10 ohms Find the E M F of the cell producing the current [The internal resistance of the cell is negligible]

es of
e of a
gnet
lB 6

8 Explain how you would trace the lines of force in the neighbourhood of a magnet

ection of
irrent
l-6
l 7
-7

9 What is an electric circuit? Describe two methods by which you could detect the existence, and determine the direction of an electric current flowing in the circuit

Phone

10 Explain the action of a telephone

ANSWERS.

FIRST PAPER,—1914

1 For the description of a spring balance see *De's Gen Physics art* 11

Take a piece of squared paper, let the X axis represent the weight in gms and let the Y axis, the extension in mm Plot the points for the given readings and draw the mean line through them The graph will be a straight line

It will be seen that to produce an extension of 40 mm a weight of about 64 gms will be necessary

2 See *De's General Physics art* 121

The vessel moves away in a direction opposite to that of the issuing jet —an illustration of the lateral pressure in a liquid (See *Gen Physics by De, Art*, 123)

3 For Archimedes' principle and its experimental verification, see *De's General Physics, art* 140

Let V be the vol of the body in c c

Then its wt = vol × density $= 8.9 \times V$

And wt in water = $8.9V -$ wt of displaced water

$= (8.9V - V)$ gms $= 15.3$ gms

Therefore $V = 15.8/7.9 = 2$ c c

4 For evaporation, See *page* 123 *Glazebrook, Heat*

" " " Arts, 120 and 122 " "

For the latter part of the question see *Art*, 121

5 We know that water (in fact any liquid) boils when the pressure of its vapour is equal to the super-incumbent pressure We are to note the two temperatures at which water boils on the summit of a mountain and its base By consulting Regnault's tables of pressure of aqueous vapour at different temperatures we can find the pressure of the atmosphere at the two places and hence their difference Very complete tables have again been constructed by which the difference in height between any two places may be readily ascertained, if the corresponding difference of pressure be known For small elevations we may assume that an ascent of 900 ft produces a depression of 1 in in the barometric height

The above comes to an approximation that an ascent of about 1080 ft produces a lowering of 1°C or that of 600 ft produces a lowering of 1°*F* in the boiling point of water

mination of sp ht of a solid, Black's method
Glazebrook, Heat Art 48, page 44

temp of the oil bath

Copper = Heat gained by ice

Copper × its sp ht × fall of temp

= Mass of ice melted × Lt ht.

$933 \times (T - 0) = 150 \times 80$

$T = 257^{\circ}$C approx

n of α, see *Glazebrook, heat Art 55*

" β " " " *63*

le given, we have the formula

$l' = l\{1 + \alpha(t' - t)\}$ (see *page 21 of this book,*

on $= l' - l = l\alpha(t' - t)$

m.m $= 50 \times \alpha \times (98 - 14)$

$= \alpha \times 50 \times 84 = 4200 \times \alpha$

$\alpha = 0.00016$

of a note, see *De—Sound Art 57*

of the question, the pitch of the fundamental
octave higher than that of the closed pipe of
Art 69, ibid)

tube vertically in the jar dipping one end in
the vibrating fork close to the upper end and
he tube over water until it speaks When the
m, the wave-length in air of the note is given
ngth of the tube over water (See *De, Sound,*
Art 74)

n of reasonance in the case of vibration of air
have $v = 4ln$

re v = vel of sound in air,
l = length of the vibrating air-column
n = the frequency of the note

$4 \times l \times 256$

32 4 cms approx

that in the experiment, maximum resonance
ength of the tube above the water-surface will

SECOND PAPER 1914

1 For the statement of the laws, see *Glasebrook, Art 33*

For the experimental verification see *Ganot Art 351*

For the second part of the question, see *Glasebrook Light, Expt 9 page 50*

2 For the geometrical construction for the formation of an image by a double convex lens, *Glasebrook, Light Art 74* and *77*

Draw a figure on the squared paper provided, after *fig 94 Glasebrook Light,* where AQ is to represent 30 cms and AF 80 cms on the same scale As the object is placed symmetrically on the axis PQ is to represent 2 5 cms not necessarily on the same scale The semi-length of the image is given by *pq* on the same scale as PQ The size of the image will be 2 5 cms

3 Describe an astronomical telescope, see *Glasebrook, Light, page 160 Art 98*

4 A pure spectrum would be obtained For figure and discussion, see *Glasebrook-Light Art* 111

5 *(a)* The insulated metallic conductor can be charged either by conduction or by induction In conduction, this is simply to be put in contact with a charged body or an electrical machine

In induction a charged body is to be brought near the conductor The induced opposite charge is attracted or *bound* by the inducing charge to that part of the conductor nearest to it, while the induced similar charge is repelled to the furthest end and passes to the earth when the conductor is momentarily connected with the latter Now remove the conductor away from the charged body, when the opposite charge will no more be bound and will spread over the whole surface of the conductor

To charge a Leyden jar by induction —Draw first a sectional figure of a Leyden jar

Place the jar on an insulating table, take the charged body (say with +ve electricity) near the knob of the jar, it will induce —ve charge on the knob and +ve charge on inner foil The latter again induces —ve charge on the inner side of the outer coating and +ve charge on the outer side

On touching momentarily the outer coating with the hand the free +ve charge on it will pass to the earth On now removing the charging body the two opposite charges on the inner coating cannot neutralise as the case has now become similar to a standard

ion where the—ve charge on the inner face of the may be regarded as holding the +ve charge on the he inner coating bound to it Now, on touching the —ve charge will pass to earth leaving the Leyden jar or charged as in the ordinary way

ond part of the question, you may describe, either ous (see *Poyser, page* 89) or an electric machine Voss machine; see *Poyser*

periment is commonly known as Faraday's ice pail -for full description see *De' Prac Physics, pp* 226-28

be either a Daniell or a Bunsen cell, see *Text book*

nple given —

ve $E = CR = 0.2 \times 10 = 2$ volts

eld about a magnet can be mapped accurately by a needle and roughly by iron filings (See *De, Practi-* *ige* 208 *etc*)

tire path through which a current flows is called an

on of a current and the determination of its direction l by two means,—

magnetic effect of a current, *i e* by the deflection of edle from the magnetic meridian (the experiment, as the O'ersted experiment see *De, Prac Physics* ie direction of the current is given by Ampere's rule-

electrolytic effect of the current When an electro-posed by means of a current, the Hydrogen and e liberated at the cathode, the electrode connected ve plate of the battery

ent pass through between two copper plates dipped nate solution, the plate on which a fresh deposit of shows that it is a cathode plate (See *Poyser*

e figure and action of a Telephone, See *Poyser*

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FIRST PAPER 1915.

Paper-setters { DR D N MULLICK, MR C W PEAKE, MR R S TRIVEDI }

Only SEVEN *questions are to be attempted All questions are of equal value*

1 State Boyle's Law Describe an experiment you would perform for verifying the law Boyle's law 11-1-4 13-1 4

A litre of air weighs 1 293 grammes at a pressure of 76 cm and temp 0°C What will be the weight of a litre of air at the same temperature, when the barometer stands at 78 cm ?

2 State the laws of the pendulum Laws of pendulum 12 1 2 13-1-2

The following readings were obtained with a simple pendulum —

Length	Time of oscillation	Length	Time of oscillation
20 cms	45 sec	80 cms	94 sec
30 ,,	55 ,,	95 ,,	98 ,,
42 ,,	65 ,,	102 ,,	1 01 ,,
55 ,,	74 ,,	115 ,,	1 07 ,,
70 ,,	835 ,,	130 ,,	1 14 ,,

Represent by a graph the relation between length and time, and find from your graph the time of oscillation of a simple pendulum of length 50 cm

3 Why does a solid appear to weigh less in water than air ? Describe a method of determining the specific gravity of a solid Sp Gr of a Solid 09 1 8 13 1 3

A piece of metal weighs 100 grammes in air and 88 grammes in water What would it weigh in a liquid of specific gravity 1 5

4 Define co-efficient of linear expansion Linear Exp 14-1-6

The length of a copper rod at 50°C is 2 00166 metres, and at 200°C it is 2 00664 metres Find its length at 0°C and the coefficient of expansion of copper

5 Why it is necessary to take account of the ressure of a gas in determining its coefficient of ubical expansion ?

200 c c of air at 15°C, is raised to 65°C ind the new volume the pressure remaining unchnged

6 How would you determine the specific graity of a liquid ?

If 90 grammes of mercury at 100°C be mixed ith 100 grammes of water at 20°C and if the reslting temperature be 22°C, what is the specific eat of mercury ?

7 Describe an experiment to show that the apour pressure of a liquid exposed to air at its boilng point is equal to the atmospheric pressure

8 Explain why, when the handle of a vibrating uning fork is pressed against a thin wooden board, he intensity of sound is greatly increased

Explain a method of determining the vibration requency of a tuning fork

9 The velocity of sound in hydrogen is 1296 5 metres per second What will be the length of a closed organ pipe filled with hydrogen which gives a note having a vibration frequency of 512 per second ?

SECOND PAPER.

VEN *questions are to be attempted All questions lue*

1 State the laws of reflection of light Show by means of a diagram that a man can see the whole of his person in a mirror, the length of which s half his own height

2 Show how to find by a geometrical construcion the position of an image formed by a thin convexlens

An object, 2 in long, is placed (symmetrically with its centre on axis) 8 inches from such a lens. Find by means of a diagram, the position and the length of the image, given that the focal length of the lens is 4 inches. [Squared paper is provided.]

3. Light from a slit is allowed to fall on a prism. State and explain with the help of a diagram what will be observed when the slit is illuminated (1) by a sodium flame, (2) with white light. — Spectrum 12 II-2

4. Describe a compound microscope and trace the path of the rays. — Microscope 12 II 4

5. Explain the meaning of the expression electrification by induction. How would you prove that positive and negative electricities are produced in equal quantities by friction? — Ice pail Expt 14 II 6

6. Explain the principle and the action of a condensing electroscope. — Condensing Electroscope 13 II 9

7. Describe any two effects of an electric current, whereby the direction of the current may also be determined. — Effects of a Current 12 II 9, 13-II 7, 14-II 9

8. What is an electro magnet? Explain (1) the action of an electric bell *or* (2) the principle of the electric telegraph. — Electro mag 12 II 9, Electric bell, Telegraph

9. Describe typical experiments to illustrate the phenomena of electro-magnetic induction. — E M Ind 09 II 5, 11-II B-4, 13 II-10

10. Describe suitable experiments illustrating the phenomena of magnetic induction. How would you determine whether a given steel rod is a magnet or not? — Mag Ind. 13 II 9

ANSWERS.

FIRST PAPER—1915.

1 For the statement of Boyle's Law and an experiment to verify it, see *De' Gen Physics Art* 167

In the example given —

The vol that a litre of air at 76 cms will occupy at 78 cms is given by

$$V^1 = \frac{PV}{P^1} = \frac{76 \times 1000}{78} \text{ c c}$$

Hence the wt of V^1 c c of air at 78 cms

$$= 1{\cdot}293 \text{ gms}$$

wt of 1 litre of air at the same temp and press.

$$= \frac{1{\cdot}293}{V^1} \times 1000 = \frac{1{\cdot}293 \times 78 \times 1000}{76 \times 1000}$$

$$= 1{\cdot}327 \text{ gms approx}$$

2 For the laws of pendulum see *Text-book* Art 86

In the graph given in the opposite page

X axis represents length in cms 1 small div = 4 cms

Y axis represents time of oscillation 1 small div = 0·2 sec

From the graph the reqd time of oscillation is found to be 0·71 sec

3 When a solid is immersed in a liquid say, water, it displaces a quantity of the liquid equal to its own volume and is consequently acted upon by an upward pressure According to Archimedes' principle, this upward pressure is equal to the weight of the displaced liquid Hence a solid appears to lose a part of its weight when immersed in a liquid

For the method of determination of the specific gravity of a solid, see *De' Pract Physics page 100 etc*

In the example given ,

Loss of wt of metal in water	= 100—88 = 12 gms
Vol of displaced water	= 12 c c
	= vol of the body
vol of the liquid displaced	= 12 c c

$2\ 00166 = l_0(1+50\times\ 0000167)$

$$l_0 = \frac{2\ 00166}{1\ 000835}$$

$\log l_0 = \log 2\text{·}00166 - \log 1\ 000835$

$= 3013882 - 0003625$

$= 3010257$

$= \log 1\ 99998$

$l_0 = 1\ 99998$ metres

cubical expansion γ of a gas involves the ...e of volume of the gas due to a rise fo ...ious that the change of volume considered ...ected by alteration of temperature Alteratind ...ge of pressure is obviously not to be counteo ...riment to determine γ must be conducted

c

n —

$\frac{V_1}{T_1}$ see *page 28 of this book*

$$- = \frac{V_1}{273+65}$$

$$\frac{200\times 338}{288}$$

$= \log 200 + \log 338 - \log 288$

$= 2\ 3010300 + 2\ 5289167 - 2\ 4593925$

$= 2\ 3705542 \qquad = \log\ 234\ 722$

$= 234\ 722$ c.c

specific heat is obviously meant for *specific*

a liquid can be determined by the method ...ing some solid of known mass and specific ...ature, immersing it in a known mass of the ...a calorimeter of known weight and then ... temperature The equation for distribution

solid

...ass of solid $\times$ its sp ht $\times$ fall in temp

$M\ S\ (T-\theta)$

Heat gained by liquid

$= $ its mass $\times$ sp ht $\times$ rise of temp

$= m\ s\ (\theta - t)$

Heat gained by calorimeter, etc

$= m'\ s\ (\theta - t)$

$MS(T-\theta t) = m\ s\ (\theta - t) + m'\ s'\ \theta - t)$

Whence s can be found

In the example given, let S be the sp ht of mercury

Heat lost by mercury

$= 90 \times S\ (100 - 22) = 7020$ S calories

Heat gained by water

$= 100 \times (22 - 20) \quad = 200$ calories,

$7020\ S \ = 200$, whence $S \ = \cdot 028$

7 See *Glazebrook, Heat, page 138 Expt 36 (a) or (b)*

8 The first part of the question is an instance of forced vibration, see De' Sound, *Art* 33 (v.)

For determining the frequency of a fork any of the following methods may be resorted to

(1) The vibroscope method

(2) Syren

(3) Resonance column (see *De Sound*)

9 For the expression for the pitch of a note emitted by a closed organ pipe, we have (see *page 63 of this book*) $v = 4nl$

Substituting in the above equation, we get

$1296\ 5 = 4 \times 512 \times l$

whence $l = 1\ 579$ metres approx

SECOND PAPER 1915

1, For the laws of reflection see *Glazebrook, Light Art* 23

Draw a diagram from the following—Draw a line AB to represent the man's height Let the mirror M be at a distance d in front of it, then draw the image, on the other side behind the mirror, equal to the object and at a distance d from the mirror Join the top of the object with top and foot of the image by two

that the portion of the
alf the image=half the

in image formed by a
74 *and* 77

nded after *fig* 93 or 94
nt 8 in, and AF' (AF)
4 in in the same scale PQ the semi length of the object is 1 in
Twice the length of pq is the size of the image

Note that as the object is placed at $2f$ from the lens, the image will be formed at $2f$ on the other side of the lens, the image being real, inverted and equal in size to the object

3 (1) With sodium light only a yellow band will be obtained on the screen formed at the same place where the yellow of the solar spectrum appears

(2) With white light a spectrum will be obtained Draw a figure

See *Glazebrook Light Art* 107 *Expt* (*a*) *and* (*b*)

4 For description of a compound microscope see *Glazebrook Light p* 165

5 When an electrically charged body is taken near to an insulated uncharged conductor, the lines of force proceeding from the former terminate at the side of the conductor nearest to the charged body, thus making that surface charged with the opposite kind of electricity The inducing charge and the induced charge are thus held 'bound' to each other At the same time an equal quantity of charge of the same sign is also induced on the conductor and is repelled to its furthest end It is 'free' to move away if a second conductor be connected with the first one This is what is meant by electrification by induction

For the simultaneous and equal development of both kinds of electricity see *Poyser p* 82 *Expt* 60

6 For the description of a condensing electroscope see *Poyser p* 434

7 The direction of a current can be determined by

(*a*) the effect of the current on a magnetic needle placed near it, and

(*b*) by the electrolytic effect of the current

(see the *answer to* Q 9—II—14)

8 For an electro-magnet see *the answer to Q 9 II—12*

For the description of an electric bell, see *Poyser page, 31*

Every electric telegraph consists essentially of three parts —

(1) a *circuit* consisting of a metallic connection between two stations and a source of electric current

(2) a *communicator* or sender for the signals from one of the stations, and

(3) an *indicator* or *receiver*, for receiving them at the other station

The manner in which these arrangements especially the last two, are effected can be greatly varied

(See *Poyser, page 308 and p 301 etc*)

9 For typical experiments to illustrate the phenomena of electro-magnetic induction see *Poyser, page 285*

10 For magnetic induction see *Poyser, pages 11-12*

If the steel rod be a magnet it will possess opposite polarities at the two ends Hence the same pole of a known magnet will attract one end and repel the other end of the given steel rod, if magnetised Otherwise there would be attraction due to induction in both the cases Hence it is said that repulsion is a surer test on the point than attraction

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1916.

Paper-setters { DR D N MULLICK, MR C W. PEAKE, MR R. S TRIVEDI }

FIRST PAPER.

Only SEVEN *questions are to be attempted*

The questions are of equal value

1 Define 'work' and 'energy' Give simple examples of transformation of energy. — Conservation of energy 11 IA-1 12 I 4 13 I-1

State also the principle of the conservation of energy

laws of the simple pendulum are in the formula $t = 2\pi\sqrt{l/g}$. Explain eaning of each symbol in the formula

e frequency of oscillation of a pendu- r minute at a place where $g = 980$ cm er second, find the length of the pen-

Archimedes' principle, and explain nable you to identify a given piece of

would you determine the specific iquid ?

en quantity of gas is allowed to ex- imes its original volume What will re it will exert, if it was originally at 750 millimetres of mercury, the tem- ining constant throughout ?

n an experimental arrangement by sult may be verified

rammes of water at 70°C are mixed mmes of water at 0°C, what will be perature ?

e five grammes of water at 0°C by an equal amount of ice at 0°C, he final temperature ?

water-equivalent of the calorimeter 1 3, and the latent heat of fusion of aken equal to 79

nguish between real and apparent ex- e case of a liquid

coefficient of expansion of mercury ne bulb of a mercurial thermometer the section of the bore of the tube n, find the position of the mercury at ust fills the bulb at 0°C ? [Neglect the glass]

7 What is meant by 'maximum pressure of water vapour'? How can it be measured at ordinary temperatures? Max press of water vapour 10 I 6

Water can be made to boil at all temperatures Indicate the conditions that are, in general, necessary Boiling Pt of a liquid

8 Explain how you would determine the velocity of sound in air Vel of Sound 12 I 8

If the length of an open organ pipe sounding its fundamental note is one metre, find the frequency of the note [Velocity of sound at the temperature of the experiment, 320 metres per second]

9 State the laws connecting the frequency of the note emitted, and the length and tension of the vibrating sonometer string, and explain how you would verify the laws experimentally' Vibration of string

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SECOND PAPER

Only SEVEN *questions are to be attempted*
The questions are of equal value

1 Define index of refraction State the condition for total reflection Total Reflection 12 II-1

A rod is partially dipped into a basin of water Explain, by means of a diagram, the appearance presented

2 Describe a simple form of spectroscope Spectroscope
Classify the various types of spectra that may be obtained, illustrating each type by an example Types of spectra

3 A rod is moved from a great distance along the principal axis of a double convex lens till it is very near the lens Image by a Convex lens 12-II 3

Explain by means of typical diagrams how the image changes

rıbe a compound microscope Ex-
ans of a dıagram how the magnıfica-
ıced

the laws of actıon between magnet

rth poles repel one another with a
dynes when their dıstance apart ıs 2
will be their distance apart when the
dynes? Find also the repulsive force
ıstance apart ıs 3 cm

ı a pıece of soft ıron rod Describe
magnetızıng ıt How would you test
polarıty? How does ıt depend on the
ıgents employed

ın the actıon of (*a*) the electrophorus,

leaf electroscope

d *B* are two ınsulated metal plates
a parallel plate condenser *B* ıs
a gold-leaf electroscope Describe
actıons ın the electroscope, when—
harged posıtıvely,
nomentarıly connected to *A*,
nomentarıly connected to earth,
nade to approach *B*,
b of glass ıs ınterposed between *A*

he nature of the electrıfıcatıon of *B*

he laws of electrolysıs

with an ıllustratıon, the effect of
ı the constancy of a voltaıc cell

rıbe an arrangement for producıng
atıon of a wire carrying current when
agnetıc field How ıs the dırectıon
related to the field?

11 What is an induced current? Describe simple experiments which typically illustrate the production of induced currents.

Electro magnetic induction
07 11 5
11 18 8
13 11 10
14 11,9
16 11 0,

ANSWERS

FIRST PAPER—1916

1 A force is said to do work when its point of application moves *in* the direction in which the force acts.

When the point of application moves in a direction *opposite* to that of the force, work is said to be done *against* the force.

If a heavy body falls to the ground, its weight does work. If we lift it up again, we must do work against its weight.

The work done is measured by the product of the force and the distance through which its point of application moves in the direction of the force.

Energy is the capacity for doing work. A body in motion is able to do work against an opposing force until it comes to rest. A body may also possess energy in virtue of its position or of the configuration of its parts. Thus a body at a height can do work when allowed to fall down; again a compressed spring in a clock supplies the energy of driving the clock.

For transformation of energy and conservation of energy see answers to *Q. 1-I-11* and *Q. 4 I-12*.

2 In the formula for the oscillation of a simple pendulum viz.,

$$t = 2\pi\sqrt{l/g}$$

t is the period of oscillation, *i.e.* the time taken by the pendulum to complete one full oscillation, or the shortest time taken to come back to its initial position in the same phase of its motion.

l is the length of the pendulum measured from the point of suspension to the point of oscillation which is approximately given by the centre of gravity of the bob.

g is the acceleration due to gravity, measured in cms per sec per sec (approx. value, 980) or in feet per sec^2 (approx. value, 32) (see De's General Physics Art 86).

12

415

xample given,

$t = 60/98$ sec

$g = 980$ cms per sec per sec

ituting in the formula given above for t

$60/98 = 2\pi\sqrt{l/980}$

$$l = \frac{98 \times 60 \times 60}{98 \times 98 \times 4 \times 9.87} = \frac{4500}{49 \times 9.87}$$

Now log $49 = 1.690$

log $9.87 = .994$

2.684

log $4500 = 3.653$

$0.969 =$ antilog 99.30.

$l = 99.30$ cm

3. For Archimedes' Principle—see De's General Physics, Art 140

To distinguish a metal from its alloy see the answer to Q *3-I-12*

For the determination of specific gravity of a liquid see De—Gen Physics—Art, 147

4 Here as the gas expands under constant temp, we can apply Boyle's Law, viz,

$$PV = P'V'$$

Here $750 \times V = P' \times (1.5\ V)$

Whence $P' = 500$ mm

The result may be verified by using a Boyle's Law apparatus as is commonly used in the laboratory (for figure see *De—General Physics Fig 185*) in which a quantity of dry air is enclosed

Let the atmospheric pressure as obtained from a barometer be π. Adjust the position of the open tube so that the difference in the mercury levels in the closed and the open arms = the difference between the atmos press π and the reqd pressure 750

Now the pressure of the enclosed air is 750. At this stage, note the length l of the enclosed air

Lower the open arm until l', the new length $= 1.6 \times l$, as the tubes are of uniform cross section the change of volume is proportional. Now determine the pressure of the gas

5 In the example given let t be the final temp

Then, heat given out by 10 gms of water in falling from 70°C to t $= 10\times(70-t)$

Heat absorbed by 5 grms of water at 0°C in rising to t°C $= 5\times(t-0)$ (1)

Heat absorbed by calorimeter and stirrer

$$= 1\ 3\times t \qquad (2)$$

But heat lost = heat gained

$$10\times(70-t) = 1\ 3\ t+5\ t, \qquad \text{whence } t=42°9\ C$$

In the second case, in addition to (1) and (2) above, we have to take account of the heat absorbed by 5 gms of ice at 0°C in being converted to water at 0°C and this is

$$=5\times 79=395 \text{ units}$$

Hence $10\times(70-t)=6\ 3t+395$

Whence $t=18°7C$

6 For distinction between real and apparent expansion of a liquid—See *Glazebrook Heat Art 76*

In the example given, we have

$$V_t=V_o\ (1+\gamma t)$$

Here $V_o=1cc$, $t=100$°C and $\gamma=1/5550$

$\therefore$ $V_t=1\ 0182$ approx

Of this volume, the portion 0 0182 occupies the bore of the tube and is of length 0 0182/001 *i e*, 18 2 cms from the bulb of the tube (The expansion of glass is here neglected)

7 A liquid gives off vapour from its surface at all temperatures and this vapour behaves like a gas and exerts pressure

Also when sufficient liquid is present to saturate a closed space with its vapour, the pressure of the vapour attains a maximum value, which is constant for a given liquid at a given temp

The maximum pressure of water vapour at a temperature can be measured by introducing a sufficient quantity of water into the torricellian space of a barometer tube and noting the diminution in the height of mercury caused by the pressure of the water vapour formed (*See Glazebrook, Heat, Expt 36*)

The condition of boiling is that the pressure of the vapour arising from it is equal to the super-incumbent pressure above the liquid It thus follows that the water may be made to boil at different temps by varying the pressure above it (See *Glazebrook, Heat, Expt 37*)

of sound in air can be determined indirectly t of Resonant air column (See *De Sound*

open pipe sounding its fundamental, we have

$= 2nl$

sound, n is the frequency of the note and l,

$= 2 \times n \times 1$

$= 160$

of vibration of ...onometer string and their ..., *Sound*, *A*...

S_COND PAPER,—1916

f refraction of a substance is a constant of the sine of the angle of incidence to of refraction when a ray passes from vacuum *See Glazebrook, Light Art 33*)

pass from a rarer to a denser medium but lways true When a ray in a denser medium f separation at an angle greater than the media concerned it is not refracted out but flected (*See Glazebrook, Light Arts 37—38*)

ped in water has the appearance of being of immersion in water (For diagram, *See* r *34*)

of spectroscope consists of —

A prism table
A collimator with an adjustable slit
An observing Telescope

(*See Glazebrook-Light, Art 104*)

are commonly obtained may be divided into

an incandescent liquid or solid—this is a con- extending from red towards the violet as the substance is gradually raised The spectra of of an incandescent lamp etc are examples

the rod where the bar leaves it, is opposite
ie bar nearest the rod (Also *See the answer*

of (*a*) the electrophorus and (*b*) the gold-leaf
sei pp 87-91

harged positively, it induces negative charge
st to A while free positive charge travels
and causes the leaves of the electroscope to

momentarily connected to B, the capacity
uch diminished, the condensing arrangement
charge remains the same, its potential is in
ated by the greater divergence of the leaves

momentarily earth-connected, free positive
the earth, and the leaves of the electros-

is made to approach B further, induction
ves of the electroscope diverge with free
ase (*a*)

lab of glass is interposed between the two,
em increases and the charge remaining the
reases and the divergence is diminished

ectrolysis are summed up in the formula
hich *w*, the wt of the iron deposited at the
e strength of the current *c*, the time of
-chemical equivalent *z* of the iron liberated

Voltaic cell, consisting of a copper plate,
rod and dilute sulphuric acid, the current
intensity due to what is called polarisation
bubbles arising out of the action of acid
te on the copper plate and weakens the

istance to its passage as gases are very

an opposite *E M F* due to which a
hydrogen bubbles towards the zinc (*See*

answer (*See Poyser, page 240 Expt 164*)

aid to be induced in a coil when it is
ing to the presence of a current in a neigh-
magnet placed near it

eriments (*see Poyser, page* 285-6)

1917.

Paper-setters { Dr D N Mullik, Mr C W Peake, Mr R S Trivedi }

FIRST PAPER

The questions are of equal value

Not more than SEVEN *questions to be attempted*

1 Distinguish between *work* and *energy* A body falls under gravity and strikes the ground Explain how the phenomenon supplies an illustration of the transformation of energy — On Energy. 16-1-1 13 1-1

Does it also illustrate the principle of the conservation of energy? How?

2 What is a *simple pendulum*? Find the length of the (simple) seconds pendulum at a place at which $g=981$ — Pendulum. 16-1-2 15 1-2

What is the exact meaning of the statement $g=981$?

Will a pendulum clock gain or lose when taken to the top of a mountain from the bottom?

3 How would you find the specific gravity and the volume of a given solid? — Sp Gr of a solid

If the specific gravity of a metal is 19, what will be the weight in water of 20 c.c of the substance? — 09-1 8 13-1-3

4 Describe an experiment to prove that air exerts pressure How is this pressure measured?

If a certain pressure is equal to that exerted by a column of mercury of height 760 m m. find its magnitude [Density of mercury $=13\ 6$

e *specific heat*

is the specific heat of a solid deter-

ece of iron weighing 200 grammes at
nersed in 20 c c of water at 20°C
ulting temperature, if the specific heat
1124

water equivalent of the calorimeter

ain a method of measuring the maxi-
e of water vapour between 0°C and

r is heated in an open vessel and
tirred Describe carefully the changes
r will undergo

e *latent heat*

found that one pound of steam at
passed into 15 lbs of water at 0°C
nperature of the water to 40°C Cal-
heat of steam

it do you unerstand by the *pitch* of

ain a method of experimentally deter-
itch of the note emitted by a given

can the velocity of sound in atmos-
e measured? How is the velocity
hanges of pressure and temperature?

SECOND PAPER.

are shadows formed? Explain, with
diagram, the formation of the umbra,
mbra caused by an opaque ball, when
luminous sphere falls on it

2 Explain fully the phenomenon of total reflexion, illustrating your answer by means of careful diagrams — Total Reflection. 1-11 1 12 11 1

Explain the phenomenon of the mirage — Mirage.

3 Investigate, with the help of diagrams, the conditions for the formation of (*a*) a real image, (*b*) a virtual image, by a plano convex lens — Image by a convex lens. 16-11-3 15-11 2

Explain how you would experimentally determine the focal length of such a lens

4 Describe an arrangement of apparatus for the production of a pure spectrum — To produce a pure spectrum. 15 11-3 14 11-4

How does the spectrum of incandescent sodium vapour differ from those of limelight and sunlight?

5 An insulated and uncharged hollow conductor is connected with a gold leaf electroscope Describe and explain the effects observed on the electroscope, when— — Ice-pail Experiment.— 15 11 5 14-11 2

(*a*) a charged ball held by a silk thread is introduced into the conductor,

(*b*) the ball is moved about inside the sphere, but is not allowed to touch it,

(*c*) it is brought in contact with the sphere,

(*d*) (*e*) the ball is taken out after the experiments (*b*) and (*c*)

6 State Ohm's Law — Ohm's Law. 12-11-6 11 11B-3

The battery resistance *b* ohms for a current of *C* amperes was found in a certain test to be as follows:—

b—	4 2	4 8	5 0	5 8	7 6	8 5	11 0
C—	0·21	0 16	0 14	0 10	0 066	0 06	0 04

Illustrate these results graphically Are they consistent with Ohm's Law? (Neglect external resistance)

ıte the laws of electrolysis.

Two plates of zinc are immersed in a ... zinc sulphate and connected to the ... of a voltaic battery. Describe and ... efly the effects observed on the two ...

... magnet is suspended at the centre of ... its plane in the magnetic meridian

No current passes

... current is passed through the coil

... he strength of the current is gradually ...

Describe the effects observed, indicating ... ce of the direction of the current on the ... n

... escribe experiments which illustrate the ... veen two currents and that of a magnet ... nt

A coil of wire has its ends connected to ... als of a galvanometer

... is rapidly rotated about the vertical ... alf a revolution and then through the ... revolution

The north seeking pole of a magnet is ... roduced into the coil and then taken ...

... ate and, as far you can, explain the effects ...

Distinguish between a permanent and a ... magnet. Explain how you would pre- ... artificial magnet whose magnetism is ...

Define magnetic moment.

ANSWERS.

FIRST PAPER—1917

N B – Do not forget to state the denomination whenever it is required in the answer

1 (a) To define 'work' and 'energy', first of all see the answer to 16 I-1 See *De's General Physics Arts 89* and *91*

Distinction—Whenever work is done, energy is either lost or gained Thus, when a body is raised to a position above the ground work is done by an external force and the body gains in energy Again, when a body is allowed to fall it comes down with increasing speed until it strikes the ground It has done some work and has lost energy in consequence Thus, the loss or gain of energy by a body or system of bodies, is measured by the work done on or upon it or against it

(b) The body at its elevated position above the ground has potential energy due to its position

When it falls down it gradually loses its potential energy and gains in kinetic energy (energy of motion) A part of the energy might be converted into heat energy due to resistances of air to the motion of the body

When the body is just about to strike the ground its potential energy vanishes , all the energy, it then possesses is Kinetic

When the body actually strikes the ground the kinetic energy is mainly converted into heat and sound energy

In cases, there may appear light and the body may rebound showing the reappearance of mechanical energy [*General Physics Art 95*]

(c) Yes, the principle of conservation of energy states that the "*total energy of any material system can neither be increased nor diminished by any action between the parts of the system though it may be transformed into different forms*" [*General Physics Art 96*

Thus in the present case, it may be proved that while the body is falling, its loss in potential energy is just equal to its gain in kinetic energy, in other words, at any point in the fall of the body its potential energy *plus* its kinetic energy is constant and is equal to the initial potential energy possessed by the body (neglecting the resistance due to air)

Similarly, when the body strikes the ground, its kinetic energy is equivalent to heat, sound etc to which it is converted

mple pendulum—A *heavy particle* suspended by a *end* This is purely a theoretical pendulum for of studying the mathematical laws of oscillation of a *De's General Physics Art, 84*]

practice, however, a heavy bob and a very fine d, but it is then no longer a simple pendulum but l a compound one where the mathematical laws of , though not strictly, but most approximately true

nds pendulum is one which makes half a complete econd

$$\text{i e} \quad t=\pi\sqrt{\frac{l}{g}}$$

re let $l=$ required length of pendulum

$$\text{Then } t=\pi\sqrt{\frac{l}{g}}=\pi\sqrt{\frac{l}{981}}$$

$$\text{Or} \quad t=\pi^2\frac{l}{981}$$

$$\therefore \quad l=\frac{981}{\pi^2}=\frac{981}{9\ 87}=99\ 39 \text{ cms}$$

means that the acceleration due to the action of ody is 981 cms per sec per sec In other words allowed to fall under the action of gravity its y second changes by 981 cms per sec

e of gravity on a mountain is less than the force at the ground, for the distance of the former from earth is greater Hence, g the acceleration, due mountain is less than that on the ground

iod of oscillation of a pendulum is given by

$$t=2\pi\sqrt{\frac{l}{g}}$$

riod increases at the mountain top, *i e* the pen- e time to finish one oscillation In other words, s

inswer without being supported by any reason mark

avity of a solid heavier than water—See *De Art 146*

er than water—*See ibid.*

The volume of a solid may be determined by the method of displacement of water—See *De, Prac. Physics, page 95*

Or, from the formula

$M = V\rho$ where ρ, the specific gravity is known—See *De, Prac Physics, page 96*

(c) In the example given

$$M = V\rho = 20 \times 19 = 380 \text{ gms}$$
$$\text{Wt in water} = 380 - \text{wt of displaced water}$$
$$= 380 - 20 = 360 \text{ gms}$$

4 (a) *Air exerts pressure*—Mention any experiment you like e g, bursting an India-rubber piece tied to the top of a vessel, the inside of which is being gradually exhausted of air or the experiment of Magdeburg Hemisphere [*Gen Physics Art 154*]

(b) Measurement of Air Pressure—Pressure is measured by the height of the column of mercury from the level of mercury in the trough on which the barometer tube stands

In the example given,

P = wt of 76 cms of mercury on unit area
$= 76 \times 13\,6$ or $10{\cdot}3\,6$ gms wt

or P may be given in dynes thus

$P = 1033\,6 \times 981$ dynes [*Gen Physics Art 158*]

5 (a) Specific heat may be defined in any one of the following ways—

Specific heat of a body is the amount of heat which must be supplied to one gram of the body to raise its temperature through $1^\circ C$

Or, It is a ratio of the quantity of heat taken up by the body to have its temperature raised through a certain range to the quantity of heat required by an *equal mass* of water to be raised through the same range of temperature

(b) Sp ht of a solid—See *De, Prac Physics page 137*

(c) In the example given,

Let θ be the common temp of the mixture

Now, Heat lost = Heat gained

Here $200\,(100 - \theta) \times 1124 = 20 \times (\theta - 20)$

$$2248 - 22\,48\theta = 20\theta - 400$$
$$2648 = 42\,48\theta \qquad \theta = 62^\circ 3C$$

6 (a) The experiment on the point required is known as Dalton's experiment Two barometer tubes are filled with mercury and then fitted over a mercury trough, The height of

mercury in either of the tubes giving the atmospheric pressure
aw a diagram of the apparatus

Into one of these tubes let water be introduced by a bent e—the water as soon as it reaches the vacuous space above mercury level in the tube is at once converted into vapour ich exerts pressure like a gas and the mercury level is seen descend in the tube Introduce some more water until the iid is no more converted into vapour but collects at the top of mercury column The vapour within the tube is then saturated l the pressure it exerts is the maximum pressure at the room iperature Put a long jacket surrounding the tube in which our is formed Make arrangements for passing water through the ket at different temperatures, from zero to hundred Care st be taken to ascertain that at any temp, there is sufficient er to saturate the vapour space

The pressure of the vapour at any temp is obtained from the erence of the height of the mercury columns in the two tubes,

It will be seen that when the vapour attains $100°C$ the mercury he vapour tube is pressed to the level of mercury in the trough reby showing that under ordinary circumstances the pressure he aqueous vapour at $100°C$ equals the ordinary atmospheric ssure

(*b*) When water is heated in a vessel convection current is set whereby the upper portion of the liquid is gradually getting ted At first bubbles of dissolved air rise away and with ring the distribution of heat and the escape of the air bubbles hastened The temperature gradually rises to $100°C$ when pressure of the water vapour equals the atmospheric pressure water is found to boil

If this is continued water will disappear in the form of steam

7 Latent Heat—is of two kinds (i) of Fusion (ii) of porisation

The quantity of heat which is absorbed by *one gram* of the stance in passing from the solid to the liquid state *without of temp* is called the Latent heat of Fusion of the substance

The quantity of heat absorbed by *one gram of* a substance pass from the liquid to vaporous state *without rise of temp* alled the Latent heat of Vaporisation

Such quantities of heat are called latent because they are not icated by a thermometer

In the Example given,

$$\text{Heat lost} = \text{Heat gained}$$

$$\text{or} \quad 1 \times L + 1(100-40) = 15 \times (40-0)$$

Here L is the latent heat to convert 1 lb of steam

$$L+60=15\times40=600 \quad L=540$$

8 (*a*) Pitch—is that property of a note which distinguishes a shrill note from a flat one. It depends upon the frequency of vibration

N. B—It will be a mistake to say Pitch is frequency It is correct to say that Pitch is measured by frequency,

(*b*) Determination of Pitch—Give any method you like *e g*, Duhamel's expt, Sonometer, Syren, or Resonant Air column, See *De, Sound, page 91*

9 Velocity of sound in air—Mention any method *e.g*, open air expt with reciprocal firing of canons between two stations (See *De. Sound, page 40*) Or Resonant air column *page 127, ibid*

For the effect of pressure and temp on velocity—*See De. Sound page 47*

SECOND PAPER—1917.

I 1 (*a*) Formation of shadows—whenever the rectilinear course of a pencil of light on one side of a body is obstructed, a shadow is formed on the other side of the body

(*b*) Here three cases are possible, viz, the diameter of the luminous ball may be greater or smaller than or equal to the diameter of the opaque ball Draw the diagram in any one case—*See Glazebrook, Light, page 8*

2 (*a*) Total Reflection—*See answer to* Q 16-6-2 Give diagrams—*See Glazebrook, Light, Ars 38*

The mirage is an optical illusion by which inverted images of distant objects are seen In the deserts the different layers of air above the heated sands possess unequal densities,, the density increasing upwards up to a certain range The ray from an object, *e g*, a tree passing obliquely through the layer of air has its path bent more and more until the angle of incidence from a layer to the next reaches the limit of critical angle between the two successive layers Here total internal reflection takes place. The ray passes upward in a direction contrary to the first until it reaches the eye of an observer, *e g* a traveller, who imagines the ray as belonging to an object above the ground but suffering ordinary reflection at the point of the ground where his line of

ound . (Here a diagram is very important—*See*

plano-convex lens is a convex or a converging our as regards production of image is the same ordinary double convex lens only in the diagrams in plano-convex lens is to be drawn

nage by a convex lens is produced when the ∞ and F, and virtual image is produced when within the focal length of the lens. (Give diagram ook It is needless to say that a point source of tak)

cas , formation of virtual images take d the eye and the dotted lines for the ays on the other side of the lens

mine the focal length of a convex lens use any in *De, Prac Physics, page, 184*

production of a pure spectrum, the following

n adjustable slit

sm placed in the position of minimum deviation the ray coming through the slit

nvex lens used either between the prism and prism and the screen

um in any cases—See *Glazebrook, Light, Art, III*

trum of Sodium vapour will be a *Line Spectrum* line only is seen which may be broken up into lines with a good prism

of lime-light is like that of an incandescent us band from red to violet is seen

trum is a case of absorption spectrum A band ed to violet is seen interspersed with dark

irtually what is known as Faraday's Ice-pail ctional Electricity

ice of the leaves of the electroscope

e, in the case if the conductor be a spherical as the ball is introduced in it, the lines of force are practically all enclosed within the sphere, tor be a cylinder there will be variation of diver-oscope as the ball is moved up and down

(c) No change in the divergence, for when the ball touches the conductor, the charge on it is neutralised by an opposite and equal charge on the inside of the sphere, while the outside charge remains as it was before

(d) If the ball is taken out after the expt (b), induction will cease to act and divergence of the leaves of the electroscope grows less and less until the leaves collapse

(e) If the ball is taken out after the expt (c), there is no change in the divergence

6 Ohm's Law—*See Text Book*

According to Ohm's Law, C amperes in a circuit is given by

$$C = \frac{E}{R+b}$$

As R is here negligible, we may put

$$C = \frac{E}{b}$$

Or $$E = b\,C = b'\,C' = b''\,C'' \text{ etc}$$

i e, the current changes with the variation of b

If the product of b and C remains constant, the observation will be consistent with Ohm's Law

Hence, multiply b and C in all cases and show that the product is not constant Therefore, the observations are inconsistent with Ohm's Law

For the graph, take b readings on the X axis and C readings on the Y axis Draw the graph It will be somewhat like a hyperbola

7 (a) For the Laws of Electrolysis—*See Ans to Q* 16—1—9

(b) The case is one of electrolysis of Zinc Sulphate with Zinc electrodes As the current passes, $ZnSO_4$ is decomposed into Zn and SO_4 ions The ions Zn are deposited on the cathode plate which thus increases in weight The ions SO_4 travel to the anode and reform $ZnSO_4$ Thus there is loss of Zn on the anode plate

8 (a) No effect

(b) Needle deflects—The force due to the current urges the N-pole to move according to Ampere's left-hand rule e g, if the current traverses the upper half of the coil so as to pass from South to North on the upper half,—the N-pole will be urged towards the west

ı' lectıon ıncreases

ɔetween two currents—There wıll be attractıon ıf ɜs the same way *e g*, ın Roguet's vıbratıng spıral

ıt pass ın opposıte dırectıons to each other, there n (Descrıbe a suıtable experıment from your that of two movable wıre rectangles suıtably ıgh which the current may be passed upwards

between a magnet and a current —The magnet ed to be traversed by an ımagınary current round movable wıre carryıng a current wıll be attracted dıng as the dırectıon of the current ın the latter r opposıte to that of the nearest ımagınary nagnet's pole Barlow's wheel ıs an ınstance of

hıs ıs not a faır questıon for an I Sc paper

ɜ first half revolutıon current wıll pass one way,— ıalf revolutıon the dırectıon of the current wıll be xplanatıon consult B Sc Text-Books

nagnet may be supposed, accordıng to Ampère's ıversed by an ımagınary current round ıts poles › a prımary current, a secondary ınstantaneous ınduced ın the coıl ın a dırectıon opposıte to that the prımary when the magnet ıs suddenly brought

nagnet ıs rapıdly taken out, another momentary ed ın the coıl,—this tıme ıts dırectıon beıng the he ımagınary ınducıng current on the magnet

permanent magnet always retaıns ıts magnetısm y one loses ıts magnetısm, when the magnetısıng of a current or another magnet ıs removed

ıron pıece may be magnetısed ın eıther of the three

(1) Sıngle Touch
(2) Double Touch
(3) Electrıc Current

one of these methods—*See Text-Book*

ıature of polarıty produced must be stated

! ,netıc Moment—ıs gıven by the product of the ıther pole and the length of the magnet

1918.

FIRST PAPER

Candidates are required to give their answers in their own words as far as practicable

Not more than SEVEN *questions to be attempted, The questions are of equal numerical value*

F ⁵O

1 Distinguish between potential and kinetic energy with illustrations. Energy 19 l-1 11 l-1

A railway train is going uphill with a constant velocity What is the source from which the energy of the train is supplied ?

Describe the various transformations of energy that go on in this case

2 Explain clearly what you understand by atmospheric pressure Atmos pressure 19-l-3 17 l-4

Describe experiments to prove the existence of of atmospheric pressure How is it determined ? If it is equal to that of 32 inches of mercury, find its magnitude [Density of mercury = 13 6]

3 Describe a method of determining the specific gravity of a liquid Sp Gr of a liquid

A Nicholson's hydrometer sinks to a certain mark in a liquid of specific gravity 0 6 but it takes 120 grammes to sink it to the same mark in water What is the weight of the hydrometer ?

4 Explain what you mean by latent heat of fusion Lt ht of fusion 09 ll 3 12 l-6 13-l 5

Find the latent heat of fusion of ice from the following data —

Weight of the calorimeter = 60 grammes
Weight of calorimeter and water = 460 grammes
Temperature of water (before ice is put in) = 38°C

Temperature of the mixture = 5°C

Weight of the calorimeter, water, and ice = 618 grammes

Specific heat of the calorimeter = 0 1

State the law connecting the volume, pres- and temperature of a gas

what temperature would the volume of a doubled if the pressure at the same time se from that of 700 to 800 millimetres of ry ?

Define specific heat Describe an experi o determine the water-equivalent of a copper neter and the specific heat of copper

Define the coefficients of linear and cubical ion How is the coefficient of linear expan- etermined in the case of a solid ?

ube whose sides are each 100 cm at 0°C d to 100°C If the sides become each 101 nd the coefficients of linear and cubical ion

A vibrating tuning-fork is placed at the of an open jar, and water is poured into the dually Explain what will happen

xplain how you would determine the velocity id in air by an experiment of this kind

Describe the motion of a sounding body would you demonstrate the nature of this experimentally ?

plain, as far as you can, the mode of propa- of sound through air

SECOND PAPER

1 Distinguish between umbra and penumbra Shadows 17-II-1

Indicate the formation of umbra and penumbra due to a spherical opstacle, when the source of light is a luminous sphere, (*a*) when the latter is larger than the obstacle, (*b*) when it is smaller, (*c*) when the spheres are equal

2 A rod is placed at a considerable distance from a concave reflecting mirror, and perpendicular to its axis Describe by means of suitable diagrams the changes in its image as the rod is made to approach the mirror, parallel to itself till it is very near the mirror Concave Mirror 13 II- 11 II-2

3 Define the following terms · Principal focus, virtual image Convex Lens 16 II 3

Illustrate the meaning of each of these terms by means of diagrams, in the case of a convex lens

A rod 5 cm long is held in front of a convex lens and forms an image 25 cm long upon a screen (placed parallel to the rod) at a distance of 100 cm from the lens What is the focal length of the lens ?

4 Describe, and explain the use of, a spectroscope Spectroscope 16-II-2 13-II 2

Describe a solar spectrum

5. Describe (*a*) the construction and the mode of action of an electrophorus, (*b*) a gold-leaf electroscope Electrophorus 16 II-7 13-II-5

6 Two similar deep metal jars are placed on the caps of two similar electroscopes at some distance apart, they being connected by a fine wire Electro static Induction

(*a*) A positively electrified ball is lowered into one of the jars without touching the sides

(*b*) The wire connexion is broken by means of a silk thread

(c) The ball is removed without touching the ides

Explain the effects observed on the two sets of old leaves

7 State Ohm's law

Two cells, each having a resistance of 2 ohms nd an E M F of 1 5 volts, are connected in series o the binding screws of a galvanometer having a esistance of 7 ohms Find the current passing rough the circuit If the binding screws are also onnected by a resistance of 7 ohms, how is the urrent through the galvanometer affected ?

8 Describe the construction of a tangent galanometer

A circuit includes a water voltameter and a tanent galvanometer State the relation between the eflexions of the galvanometer and the amounts of ydrogen liberated

9 Expain the action of 'Barlow's Wheel', or ny arrangement for producing continuous rotation y electrical means

Describe typical experiments which support the xplanation you give

10 Describe the construction of an electroagnet How does it differ in construction and ction from (a) a natural magnet, (b) an artificial agnet ?

How would you use it to demonstrate the ature of induced currents ?

ANSWERS.

FIRST PAPERS,—1918

1 For the distinction between potential and kinetic energy as well as for their illustrations see *De's General Physics, Art, 91*

For the source of energy of the train see the answers to Q 1911-I-1, p 130 The transformations of energy in this case are -

(1) Change of potential energy in the coal to heat energy and

(2) Use of Heat energy partly to overcome friction on the way and partly to overcome the effect of gravity.

2 For the meaning of the atmospheric pressure see answer to Q 1917-I-4, see also *De's Gen Physics, Art 154*

To prove the existence of the above cite experiments with the Magdeburg Hemispheres etc *See De's Gen Physics, Art 154*

It is determined by noting the height of mercury standing in a baometer tube over the level of mercury in the cistern below

The magnitude is given thus ,—

Vol of mercury standing on 1 sq in	=	32 cu in
Wt of 1 cu ft of water	=	62 5 *lbs*
Wt of 1 cu ft of mercury	=	62 5 × 13 6 *lbs*
Wt of 32 cu in of mercnry	=	$\frac{62\ 5 \times 13\ 6 \times 32}{12^3}$
	=	15 7 *lbs,*

3 For the method of determining the specifie gravity of a liquid see *De's Gen Physics, Art 147*

Let vol of hydrometer up to the mark = V cc

Let wt of hydrometer = W gms

Then $V \times 0\ 6 = W$

Again from the floating condition for the hydrometer in water

$V = W + 120$

From the above $W - 0\ 6 = W + 120$

$W = 0\ 6W + 120$

Or $0\ 4\ W = 72$ W = 180 *gms.*

f the latent heat of fusion *see Glazebook, p* 38

sion of ice = L units

= 460−60 = 400 *gms*

ater = 60×0 1 = 6 *gms*

= 618−460 = 158 *gms*

= Heat gained

cal by ice

) = 158 (L+5)

= 79 8 heat-units

t

the volume of a quantity of a gas at
= t^0 c+273), and P' and V' are the
of the same quantity of the gas at

he example given,—

$\times 2V$

$+t'$

, and hence t' cannot be worked out
aken as zero, then

$\frac{16}{273+t'}$

16 × 273

9 × 273

9 × 39 = 351° C

specific heat *see Glazebrook,—Heat*

water-equivalent of a calorimeter,—
m gms) of water at the room
weighed calorimeter (say of *m'* gms)

Pour into it a quantity of hot water (say at T^oC) Let θ be the common final temperature of the mixture After a final weighing of the calorimeter determine the weight of the hot water poured (say M gms) Let w be the water-equivalent of the calorimeter Then

	Heat lost by hot water	=	Heat gained by water and calorimeter
Or	$M(T-\theta)$	=	$(m+w)(\theta-t)$
whence	w is known		
Again	as $w = ms$ (see p 35)		

s also is obtained from this

7 The co-efficient of linear expansion of a solid is its increase in length of unit length per unit rise of temperature Thus

$$\alpha = \frac{l'-l}{l \times t}$$

The co-efficient of cubical expansion of a body is its expansion per unit volume per unit rise of temperature Thus

$$\alpha = \frac{V'-V}{V\ t}$$

The coefficient of linear expansion of a solid may be determined

(1) *by Lavoisier and Laplace's Method* See Glazebrook,—Heat, Art 58

Or (2) by *Pullinger's Apparatus* In this a rod is supported vertically in a frame, the upper end of which projects a little above a perforated glass plate placed on the frame work The rod has a steam-jacket round it The expansion of the rod is measured by means of a spherometer placed on the glass plate, its central foot touching the upper end of the rod

Or (3) by the *Micrometer Method*—See Glazebrook,—Heat Art 59

For the example given,—

$$\alpha = \frac{l'-l}{l \times t} = \frac{101-100}{100 \times 100} = \frac{1}{10^4} = \cdot 0001$$

and $\gamma = 3\alpha = \cdot 0003$

8 The jar will, after a time, 'speak' i e, it will resound to the tone of the fork See the article on Resonance in *De's Sound* Art 41

ıe velocıty of sound ın aır ıs determıned from the relatıon λ See *De's Sound*, art 79 p 129

The soundıng body makes perıodıc oscıllatıons whıch may be *verse* or *longıtudınal* See De's *Sound*, Art 5

he nature of the motıon may be experımentally demonstrated tachıng a style to the body by means of wax or otherwıse, and g ıt press lıghtly on a pıece of smoked paper wound round a as ın *Duhamel's Vıbroscope* See *De's Sound*, Fıg 47

or the mode of propagatıon of sound through aır see *De's Sound*, 7

Second Paper —1918

Umbra means real shadow whıle penumbra means a mıxture adow and lıght When the lumınous source ıs a poınt, we get the a only, wıth a source of some sıze both the umbra and penumbra obtaıned

or the dıagrams ın the three cases see *Glazebrook,—Lıght* 8

Some sıx dıagrams are here to be drawn See the answer to 911-II-2

Prıncıpal Focus—If a *small* pencıl of *parallel* rays fall on a rıcal mırror or a lens ın a *dırectıon parallel* to the prıncıple axıs, ays after *reflectıon* or *refractıon* do actually *converge to* or *ar to dıverge* from a poınt on the axıs, thıs poınt ıs called the cıpal Focus of the mırror or the lens as the case may be

ırtual ımage —See *Glazebrook,—Lıght Art 25, page 34*

or the dıagram of the Prıncıpal Focus of a convex lens,—see 86, *Glazebrook,—Lıght*

For the dıagram of a vırtual ımage produced by a convex lens *fig 92, Glazebrook, art 77*

Example —

$$m=\frac{I}{O}=\frac{v}{u}$$

$$\text{or}\quad \frac{25}{5}=\frac{100}{u}$$

$$u=20\ cm$$

now $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$ as the image is real

or $\frac{1}{100}+\frac{1}{20}=\frac{6}{100}=\frac{1}{f}$

$f=16\frac{2}{3}$ *cm*

4 Spectroscope,—this instrument is used to detect the present of certain elements in a substance by rendering it luminous by suitable means and then examining its light

Then see the answer to Q 1916-II-2

The spectrum of sun light is a coloured band from red to violet crossed with numerous dark lines, called Fraunhofer's lines See answer to Q 1913-II-2

5 Elctrophorus—See *Poyser*, pp 87-91

Gold-leaf electroscope—see *De's Prac Physics, page 229*

6 (*a*) As the ball positively charged is introduced within jar no 1, it induces bound negative charge inside it and an equal quantity of induced positive charge which spreads over the outside of the two jars As the jars are similar, each will get half of this positive charge Hence there will be equal divergence of the leaves in the two electroscopes

(*b*) No change

(*c*) Part of the induced negative change which now becomes free, neutralises the positive charge on the jar no 1 Owing to the rest the leaves now diverge with negative charge Leaves in the electroscope no 2 are un-affected

7 Ohm's Law—see answer to Q 1917-II-6

Draw a figure first In the first case

$$C=\frac{E}{R}=\frac{2\times 1\ 5}{2\times 2+7}=\frac{3}{11}\text{ amp}$$

In the second case, the equivalent resistance of the shunted galvanometer is given by

$$\frac{1}{R}=\frac{1}{r_1}+\frac{1}{r_2}=\frac{1}{7}+\frac{1}{7}=\frac{2}{7}$$

$$R=7/2 \text{ ohms}$$

Hence the current in the circuit

$$C_1=\frac{E}{R_1}=\frac{3}{4+7/2}=\frac{2}{5}\text{ amp}$$

rent through the galvanometer

$$=\frac{s}{s+g}\ C=\frac{7}{7+7}\times\frac{2}{5}\text{ amp}$$

$$=\frac{1}{5}\text{ amp}$$

anometer—see answer to Q 1913-II-8

nt galvanomer

$C=k\tan\theta$

of hydrogen evolved in the water voltameter

$W=ect$ (see *Poyser page 271*

r each second varies directly as the deflection
ranometer

el—see answer to Q, 1912 II-10

explained by the application of *Fleming's rule* magnetic lines of force in the field and the nt and of the motion generated For typical ate the rule, see *Hadley's Magnetism and Elec-urse*)

so be explained by imagining a magnet to be a an invisible current traverses (*Ampère's theory* ien applying the theory of mutual attraction allel currents (See *Poyser, Magnetism and and 230*)

net—see answer to Q 1911-II-10

round which a coil of insulated wire is wound ses, the magnetic field of the current acts in-on and magnetises it As soon as the current almost all its megnetism

as well as an artificial magnet have got perma-atural magnet has an irregular shape but an erally of a horse-shoe shape Artificial magnets e, a horse-shoe shape, a lozenge shape etc

agnets in place of the primary coil in experi-gnetic induction in Poyser pp 285 6

1919.

FIRST PAPER

Candidates are required to give their answers in their own words as far as practicable

Not more than SIX *questions are to be attempted*
All the questions are of equal value

1. Explain clearly the meaning of the terms 'work' and 'energy' Illustrate your answer by examples — Energy 16 l-1, 17 l-1

A body is projected upwards with a velocity of 64 feet per second Represent graphically its kinetic energy at any height during the upward journey. [$g=32$]

2 Define a 'seconds pendulum' — Pendulum, 17-l 2

Find the length of a seconds pendulum at a place at which $g=981$ C G S units

Will a seconds pendulum gain or lose when taken to the top of a mountain? Give reasons for your answer

3 Explain fully the meaning of the statement 'The atmosphere exerts a pressure of 15 lb per square inch, nearly' — Atmos Pressure 18 l 2, 17 l 4

How would you verify the statement experimentally?

4 State Archimedes' Principle — Archimedes' Principle 16 l-3, 14-l-3, 12-l 3

How would you demonstrate its truth?

A body weighs 62 grammes in vacuo and 42 grammes in water, find its volume and specific gravity

5 100 grammes of water at 20° C is mixed with (*a*) 25 grammes of ice at 0° C, (*b*) 25 grammes of water at 0° C Find the final temperature in each case Explain the difference bet — Calorimetry

1 the two results as far as possible [The
nal capacity of the vessel to be neglected]

Describe the construction of a mercurial
nometer It is necessary that the tube should
of uniform bore throughout ? Give the reason
our answer

tate the relative advantages of mercury and
iol as thermometric substances

Distinguish between conduction and con-
on of heat

lustrate the difference by examples

vessel containing water at the temperature of
iom is connected with an air-pump, and the
ned air (above the water) is exhausted Ex-
the effects observed

Discuss, as far as you can, the nature of
rations in air when sound is transmitted
h it

the case of a musical note, what characteris-
the vibration determine its pitch and loud-

How does the pitch of the note emitted by
hed string depend on the length and the
il of the string ?

en two tuning-forks, how would you deter-
ie pitch of the note emitted by one of them,
of the other is known ?

SECOND PAPER.

ore than SIX *questions are to be attempted*
All the questions are of equal value

State the laws of reflection of light How
ou verify them ?

Explain with the help of diagrams the formation of multiple images by two mirrors, (*a*) when they are parallel, (*b*) when they are inclined to each other at 90° — Two mirrors

2 State the laws of refraction of light — Refraction of

Why is it that a pond of clear water appears less deep than it really is? — 14 II 1, 12-II-1

The real depth of a pond is 6 feet Find its apparent depth if the index of refraction for water is $\frac{4}{3}$

3 Explain the formation of images through a double convex lens, by means of typical diagrams [Explain the construction in each case] — Convex lens 18 II-3, 17-II-3, 16 II-3, 15-II-2 etc

4 You are given two convex lenses of local length 20 cm and 1 cm respectively How would you arrange them to form a telescope? — Telescope 14 II-3, 12 II-4

Draw a diagram showing the course of the rays through the combination, and find the magnifying power

5 Describe the construction of a Leyden jar, and explain the mode of charging it — Leyden jar 14-II-5, 13-II 6

(*a*) If the jar is placed on an insulated stand when being charged, how would the final result be affected?

(*b*) If the glass is replaced by shellac, what will be the effect?

6 A hollow insulated conductor is electrified positively A gold-leaf electroscope is electrified negatively A small conducting sphere connected to the electroscope by a thin wire is (*a*) introduced into the conductor, (*b*) moved about while inside Describe and explain the effects — Electrostatic induction

What difference will it make if the electroscope is positively electrified?

7 Describe the construction and explain, as

Voltaic cell
12-II-7
11-I-6

far as you can the action of a voltaic cell [Grove's or Daniell's].

State, in general terms on what the 'electromotive force' of the cell depends.

Electrolysis
17-I-7
16-II-9

8. State the laws of electrolysis.

Describe a water voltameter, and explain how you would use it for the verification of these laws.

Electro-magnetic induction
16-I-11
15-II-9
13-II-10 etc.

9. What are induced currents? Describe typical experiments whereby production of induced currents may be illustrated.

10. A small magnetic needle is suspended on a vertical pivot. How would it place itself, and why?

Magnetic effect of a current
10-II-10

A wire carrying a current is held horizontally, (a) along (b) perpendicularly to the magnetic needle above its centre. Explain the effects observed.

The current is (a) increased in intensity (b) reversed in direction. What will be the effects? Why?

ANSWERS.

FIRST PAPER,—1919

N B Note that six questions are to be answered In case where more than six are attempted, examiners generally consider the six best answers

Further a student should never omit to state the denomination whenever it is required in the answer

1 For the meaning of 'work' and 'energy' see the answer to 1917-I-1 For examples see *De's Gen Physics, Arts 89 and 91*

For the example given,—

$$v^2 = u^2 - 2gs$$

Here $= 64^2 - 2 \times 32s = 64^2 - 64s$
$= 64(64 - s)$

The kinetic Energy (K E) of a particle of unit mass

$$= \tfrac{1}{2} mv^2 = \tfrac{1}{2} v^2 = 32\,(64 - s)$$

Now to draw the required graph, let the X—axis represent S and the Y—axis the K E viz, 32 $(64-s)$ Give different values to S *e g*, 1 ft 2 ft 3 ft etc to 64 ft the K E will be 32×64, 32×63 32×62 etc, etc to 32×0 Plot these points and join them The graph is a straight line

2 For the answer to the whole of this question see the answer to Q 1917-I-2

3 A layer in the atmosphere is subjected to the weight of the superincumbent layers and hence it exerts a pressure Ordinarily this pressure is not felt as it is exerted in all directions (*Pascal's Law*) But if the air on one side of a surface be removed somehow or other, then the existence and the intensity of the air pressure on the other side of the surface is at once evident See *Expt 93 De's Gen Physics Art 154*

The statement can be experimentally verified by means of a Mercury Barometer, in which a mercury column of a definite height is supported by the atmospheric pressure This height is on an

average about 30 inches The weight of a volume of mercury of 30 in height and one sq inch in area is given by

$$\frac{30 \times 1 \times 62\ 5 \times 13\ 6}{12 \times 12 \times 10}$$ (See *De's Gen Physics Art 158*

$= 14\ 75$ lbs $=$ 15 lbs approximately

4 For the statement and proof of Archimedes' Principle see *De's General Physics, Art 140*

For the example given,—

Loss of wt of body in water $= 62 - 42 = 20$ gms

This is the upward pressure exerted by the volume of water displaced by the body according to Archimedes' Principle

Vol of displaced water $=$ 20 c c

$$\text{Sp Gr, of body} = \frac{\text{Wt of body}}{\text{Wt of eq vol of water}}$$

$$= \frac{62}{20} = 3\ 1$$

N B—no unit

5 (*a*) Ice at $0°C$ to be converted into water at $0°C$ requires a total amount of the latent heat

$25 \times 80 = 2000$ calories

Again 100 gms of water at $20°C$ in cooling to $0°C$ can supply $100\,(20-0)$ i-e 2000 calories which will, as we see, just melt the ice So the final result is 125 gms of water at $0°C$

(*b*) Let θ be the common final temperature

Now Heat lost $=$ Heat gained

Or $100\,(20-\theta) = 25\,(\theta - 0)$

Or $2000 - 100\,\theta = 25\,\theta$

Or $125\,\theta = 2000$, whence $\theta = 16°C$

6 In the construction of a mercurial thermometer the successive steps are the following —

(1) *Selection of tube* —The tube should have a *capillary* and a *uniform* bore It is next cleaned and dried

(2) *Blowing a bulb* at one end and making a construction at the other where a funnel is attached by means of an indiarubber piece

(3) *Filling* the bulb and a part of the stem with mercury by alternate heating and cooling

(4) *Sealing* —The apparatus is to be heated at a little higher temperature than the highest at which the thermometer is to be used

(5) *Determination of Fixed Points* viz, the ice point and the steam-point, In the determination of the former, the bubb is dipped in powdered ice In the latter case, the thermometer is inserted in a Hypsometer to be surrounded by steam only at the pressure in the room To this then a correction is applied for the deviation of this pressure from the normal pressure as the boiling point of a liquid varies with the pressure

(6) *Graduation* of the stem between the ice-point and the steam-point

It is necessary that the tube should be of a uniform bore as otherwise the graduations on it will be irregulas

Advantages of a mercurial thermometer —Mercury has a high boiling point (viz, 350°C about), low specific heat, a high and regular coefficient of expansion, good conductivity, opacity etc etc

Advantages of an *alcohol* thermometer —Alcohol has a high coefficient of expansion and possesses a much lower freezing point, hence it is specially suitable for low temperature work

7 Conduction of heat —Heat is said to be transmitted by conduction when it passes from the hotter to the colder parts of a body, or from one body to a colder body in contact with it (See *Glasebrook —Heat Art 137)*

Solids are heated by conduction It is a slow process

Convection of heat —Heat is transmitted by convection when material particles conveying the heat are carried from one point to another (See Glazebrook —Heat Art 137)

Liquids and gases are heated by this process Heated portion of these go up and the colder portion from the sides occupy the place It is a slower process than conduction

(*b*) As the exhaustion goes on the pressure over water in the vessel falls until the reduced pressure becomes equal to the pressure of the water vapour at the room temperature Now a liquid boils when the pressure of its vapour equals the superin cumbent pressure above it Hence the liquid in the vessel with then bigin to boil

Due to still continued exhaustion and boiling vapours in large quantities will rise from the liquid mass and latent heat will be abstracted from it Finally the water in the vessel will freeze

8 Air vibrations are longitudinal when sound is propagated through it See *De's Sound Art 7* Give diagrams

Pitch is determined by frequency i e no, of vibrations per second executed by a body

Intensity of a note is determined by the amplitude of vibration Loudness depends upon the intensity of a note and the acuteness of hearing of an observer (*See De's Sound, Art* 39)

9 Cite here the laws of the vibration of a string concerning the variation of *n* with *l*
and Do Do with *m*

(See *De's Sound, Art 66*)

And for their verification with a sonometer wire see *De's Sound, Art 66* (*A*)

For the determination of the unknown frequencies of the fork see Expt 22 (A) in *De's Sound, Art 66* (*A*) This may also be done with a resonance column of air (See *De's Sound, Art* 79)

SECOND PAPER

1 For the laws of reflection of light and for their verification see *Glazebrook,—Light Art* 23 *and* 24 *or Ganot, Art* 332

(*a*) For the Diagram of the position of images formed by two parallel plane mirrors see *fig* 24 *Glazebrook,—Light Art* 30

(*b*) When the mirrors are inclined to each other at 90°, see *fig* 27, *Glazebrook, Art* 30

2 For the laws of refraction see *Glazebrook,—Light, Art* 33

It is due to refraction that the bottom of the pond seems to be raised up In *fig* 33 *of Glazebrook,—Light, page* 50 let PQ represent a bit of the surface of the bottom of a pond Rays proceeding from this suffer a refraction at the surface of water and give rise to a refracted image P′Q′

For refraction at a plane surface the expression for v is given by

$$\mu = \frac{u}{v}$$

$$\text{Here} \quad \frac{4}{3} = \frac{6}{v}$$

$$v = 4 \cdot 5 \text{ ft}$$

3 To trace the formation of an image by a convex lens two rays are to be drawn See *Glazebrook, Light, Art* 74

Draw two diagrams, one showing the formation of a real image, the other a virtual image See *figs* 92 *and* 93 *of Glasebrook,—Light, Art* 77

4 For the diagram of rays through the two lenses which form a Telescope see *fig* 111 *of Glasebrook, Light, Art* 98

The magnifying power is given by F/f See *the same article*

Here $m=\frac{F}{f}=\frac{20}{1}=20,$

5 For the construction of a Leyden jar see *Poyser page* 122

For the mode of charging this—see the answer to Q 1914-II-5(*a*)

(*a*) See the answer to Q 1913 II-6(*a*)

(*b*) As the inductive capacity of shellac is less than that of glass, the capacity of a Leyden jar will be less when shellac is used instead of glass

6 Draw a diagram first Let

C — the hollow insulated conductor
E — the gold leaf electroscope
S — the conducting sphere

(*a*) When S goes within C, a condenser is formed Positive charge will come to the inner surface of C and induce bound −ve charge on S and drive the induced +ve charge to E Hence the divergence of the leaves will diminish

As S is introduced more and more, the capacity of the condenser so formed increases and more induction takes place Hence the divergence is gradually less and less They will then collapse and then diverge again with positive electricity

If E is charged positively to begin with, the divergence of the leaves will not diminish but will go on increasing from the instant of introduction of S within C

7 Grove Cell See *Poyser, Magnetism and Electricity p* 194

Daniell Cell See *ibid page* 192

The 'Electro-motive force' of a cell depends upon the nature of the plates used in the cell and does not depend upon the size of the plates The greater the distance between the two metals used as plates in the Electromotive series, the greater the difference of potential and the E M F of the cell

The position of a substance in the list again varies considerably with (*a*) its condition and (*b*) the strength and nature of the liquid (See *Poyser page*, 188)

8 Laws of electrolysis—see the answer to Q 1916 II 9 and *Poyser, page*, 272

Water-voltameter—see *fig* 233 *Poyser page* 265 and its description The tubes O and H are long and graduated so that the volumes of the gases can be measured

Now for verification of the laws we have W, the weight of an ion were, say Hydrogen, in one of the tubes is proportional to *C* and *t* So vary *C* first and calculate the weight of hydrogen collected from the volume observed, the observed volume is, of course, reduced to N T P for this purpose In calculating the pressure of the gas the tension of aqueous vapour at the temperature of the water in the voltameter must be taken into consideration Then proceed in the same way by varying *t* but keeping *C* the same

9 See Poyser—*Magnetism and Electricity pp* 284-286 Do not omit to insert the excellent table given here

10 The magnetic needle supported on a vertical pivot is an ordinary compass needle It will place itself in the magnetic meridian one end pointing towards the magnetic north and the other towards the south As the earth is a magnet, its surface is a magnetic field, its lines of force running from the south towards the north The magnetic needle simply places itself along and parallel to these lines of force at the place of the experiment

(*a*) Wire held *along* the needle Needle will deflect according to Amperes' Swimmer Rule is Maxcel's corkscrew rule With is increased current, the deflection is greats, with current reversed in direction the deflection will be in the opposite direction

(*b*) Wire perpendicularly to the needle and horizontally One end will dip a little With reversed current the other end bends down With increased current the bending should be greater as far as the support allows

All these results are explained by the fact that whenever a current traverses a wire, it creates a magnetic field of which the lines of force are circular, the direction of the lines of force being given by the Cork-screw Rule

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Another New Book :—

AN

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to

The Study of Light

by

Prof R DE

and

Prof N N DE

In the Press]

1920

FIRST PAPER

Not more than SEVEN *questions are to be attempted*
All the questions are of equal value

Explain what is meant by *mass* and *weight* and how they are measured

A body is weighed at the surface of the earth at sea level and at the top of a mountain State, in general terms, how the position will affect the weight and the mass of the body Give reasons for your answer as far as possible

Mass and weight

2 Explain clearly, with illustrations, what is meant by energy of a body State the *principle of conservation* of energy.

If clouds were one mile above the earth and rain fell, sufficient to cover one square mile at sea level, $\frac{1}{4}$ inch deep, how much work was done in raising the water to the clouds?

Energy conservation of energy
13-1-1
12 1-4
11 1-1

3. State Archimedes' principle How can it be verified experimentally?

A piece of glass weighs 8·6 grammes in air, 5·85 grammes in water, and 6·4 grammes in alcohol Find the specific gravity of alcohol

Archimedes principle
19 1 4
16 1 3
14 1-3
12 1 3

4. A volume of air at standard temperature and pressure is compressed to $\frac{1}{6}$th of its original volume What will be the new pressure?

Describe an experimental arrangement which will enable you to verify the result

On Boyle's Law
16 1-4
15-1-1
13-1-4
11 1 1

5 The height of a barometer appears to be 76 4 cm according to the brass scale which is correct at 0°C If the temperature at the time of reading is 30°C what is the actual height of the mercury column? The coefficient of linear expansion of brass is 0 000018 How is this quantity determined experimentally?

Linear expansion
18 1-7
15 1-4
14-1-7
etc

n by 'latent heat' and how

nent by which the latent
y be determined

an experiment to deter-
of a solid Indicate the

vacuum of a barometer
drop by drop Indicate
e in that space may be
What will be the ulti-

he mechanical equivalent

2 00 grammes falls from a
the energy is converted
of heat developed Me-
t=4 2 × 10⁷

he motion of the air be-
ator, e g, a vibrating tun-

transverse vibration of a
be experiments to verify

ND PAPER—1920

tions are to be attempted
re of equal value

ce between a real and a
ve a convergent lens of

12 inches, focal length, show by sketches where you would place an object, so as to obtain by means of the lens, (*a*) a real,

(*b*) a virtual image

Convex Lens, 18-ll-3 17-ll-3 16-ll-3 15 ll-3 etc.

2 Describe how you would project a pure solar spectrum by means of a spectroscope How are the dark lines explained ?

Spectrum 18-ll-4 17-ll-4 Spectroscope 18-ll-4 16-ll 2

3 Define the focal length of a mirror

Concave mirror 18-ll-2 13-ll-3

An object is at a distance of 10 cm from a mirror and the image of the object is at a distance of 30 cm. from the mirror on the same side as object

Is the mirror concave or convex ? What is its focal length ?

4. Describe a telescope Explain by means of a diagram how the magnification is produced

Telescope 19-ll-4 14-ll-3 12-ll-4

When is the image erect and when is it inverted ?

5 Describe an experiment which will show that a piece of iron attracts a magnet, just as truly as the magnet attracts the iron

Mag Induction 15-ll-10 13-ll-9

Illustrate by suitable experiments the phenomenon of magnetic induction

6 What do you mean by potential of a conductor ?

Electric Potential

Two conductors of capacity 10 and 15 respectively are connected by a fine wire and a charge of 1,000 units is divided between them. Find the potential of either conductor and the charge of each

Capacity

Induction
09 11-6
18 11-6
17 11 6
etc

7 An electroscope is surrounded by a cylinder of wire gauze which is put to earth If an electrified body is brought near to it, how will the leaves behave? Give reasons for your answer

Ohm's Law
18 11 7
17 11 6
12-11-6
etc

8 State Ohm's law

Two cells, each having a resistance of 2 ohms and E M F. of 1 5 volts, are connected in series to the binding screws of a galvanometer having a resistance of 6 ohms Find the current through the galvanometer.

Simple
Galvano
meter
18 11-8
17 11 8
Telephone
14-11-10

9. Describe the construction and action of

(*a*) a simple galvanometer,

(*b*) a telephone.

Electro
lysis of
water
19 11-8
17-11-7
16 11-9 etc

10 Describe an arrangement for obtaining oxygen by the decomposition of water

Point out the most important difference between electrical conduction in metals and in solutions.

ANSWERS

FIRST PAPER—1920

1 *Mass*—the total quantity of matter contained in a body

Weight—the effect of gravity on the mass of a body It may vary from place to place on the surface of the earth while the mass remains constant Again as the mass is changed, i e, added to or subtracted from its weight also changes (See *De's General Physics*, Art 10)

Masses are measured or compared by means of an ordinary balance by the process of weighing

Weight of a body is the total force exerted by gravity on it and is measured by the forces of elasticity of an elastic body, e.g., a spring balance A larger weight suspended from the hook of a spring-balance will extend the coil through a longer distance than a smaller weight. (See *De's General Physics*, Art 11)

A body when carried from the sea-level to the top of a mountain will have its mass unchanged, but its weight will be affected Now the weight of body of mass m is the result of the force of attraction exerted between the body and the earth As a body, in being taken to the mountain top, is at a greater distance from the centre of the earth where the force of gravity is supposed to be exerted, the force of attraction exerted by the earth on the body gets smaller since the force varies inversely as the square of the distance between the body and the centre of the earth Hence the weight of the body diminishes (See *De's Gen Physics*, Art 105)

2 Energy of a body is its capacity for doing work A body can have energy either due to its position or due to its being in motion A raised weight, a spring wound up a piece of iron seperated from one end of a magnet are all in a state of having potential energy A falling body, a flying bullet, a running stream all possess kinetic energy (See *De's Gen Physics Art 91*)

The Principle of conservation of energy states that "the total energy of any material system can neither be increased nor diminished by any action between the parts of the system, though it may be transformed into any of the forms of which energy is susceptible." (See *De's Gen Physics, Art 97*)

For the example given,—

The unit of work in the English system is the *foot-pound* which is the work done in lifting a mass of 1 lb vertically through 1 ft

Here m = mass of water of volume 1 sq mile × ½ in

$$= (1760 \times 3)^2 \times \frac{1}{2 \times 12} \text{ cu ft.}$$

$$= (1760 \times 3)^2 \times \frac{1}{2 \times 12} \times 62.5 \text{ lbs}$$

for 1 cu ft. of water weighs 62.5 lbs

and this mass has been raised through the height of 1 mile i.e., 1760×3 ft.

Hence the work done in this case

$$= (1760 \times 3)^3 \times \frac{1}{2 \times 12} \times 62.5 \text{ ft lbs}$$

mmersed in a liquid *seems*
is equal to the weight of the

ciple proceed as in experi-

$$\frac{\text{Vol of alcohol}}{\text{Vol of water}}$$

$$= \frac{2\,2}{2\,75} = 0\,8$$

case is not altered, the case

original value, the pressure

xperiment 106, art 176, *De's*
o the extent allowed by the
volume to one-sixth exactly,

f temperature in mercury
ount The correct reading
n of scale for 30° difference

rass may be determined,—
Method See Glaze-brook,

see above, Art 59
see the answer to Q 7—I

by *unit mass* of a given
to the liquid state at the
be constant and is called
e So long as fusion goes
he term *latent* is due to

the early scientists who thought that the heat absorbed without rise of temperature during fusion became latent or hidden in the liquid, and re-appeared when the liquid solidified It is now known that heat is a form of energy, and that the latent heat absorbed by any substance during fusion is converted into molecular potential energy, and supplies the increase of molecular potential energy which accompanies the change from the solid to the liquit state

Similar is the explanation in the case of the latent heat of vapourisation in the case of a liquid, what is the quantity of heat absorbed by *unit mass* of a given liquid in changing to gaseous state *without any rise in temperature*

For the determination of the latent heat of fusion of ice see *De's Prac. Physics, p 140*

7 For the description of an experiment to determine the specific heat of a solid see *De's Prac, Physics, p 137*

The chief sources of error in this experiment are—

(1) Cooling due to radiation while the hot body is dropped into the calorimeter The final temperature would have been higher, had not heat escaped to some extent to the room—from the calorimeter Either radiation correction is to be made or the calorimeter must be put inside a wooden box covered with flannel

(2) The body must be heated in dry hot air instead of in hot water as otherwise some amount of water is sure to stick to the hot body when it is transferred to the calorimeter

(3) The thermometer in the calorimeter should be sensitive to one-tenth of a degree

(4) The water equivalents of the calorimeter and thermometer must be taken into account (See *Glasebrook Heat, p*)

8 *Dew Point*—The temperature at which the quantities of water-vapour actually present in the air is just sufficient to saturate, it has been called the dew-point. Any excess of water-vapour, if present, would be deposited in the form of dewdrops

(*Glasebrook Heat, p*)

In the case given, as soon as water comes to the Torricellian vacuum, it is at once converted into vapour which exerts pressure like a gas The mercury surface within the tube being thus pressed down descends At any time the pressure of the vapour, therefore, is determined by the difference of the correct barometric height and the height of the mercury column now standing within the barometer tube when the water has been introduced into it

ing water drop by drop within 'hen the space above the mercury ater-vapour at the temperature water can be converted into must remain as water on the of the water vapour will attain the , so long as the temperature is

"echanical Equivalent of heat see

) gms falls from a height of 300

$gh = 2000 \times 300 \times 981$ ergs

$$J = \frac{2000 \times 300 \times 981}{4 \cdot 2 \times 10^7} \text{ calories}$$

$$\frac{6 \times 6 \times 981}{10^7 \times 4\,2} = \frac{6 \times 981}{4\,2 \times 10^2} \text{ calories}$$

$= 14\,1$ Calories approx.

he air between a vibrating fork

se vibration of a stretched string

e laws see *De's Sound Art 66(A)*

SECOND PAPER—1920

oceeding from a point of an object ally pass through a point in the ved on a screen.

oceeding from a point of an object n' to diverge from a point in the only by an eye but cannot be

int of a converging lens of 12 in Principal Focus so that object , the image will be a real one. *Glazebrook*

If an object be placed between the F and the middle point A of a convergent lens, its image will be a virtual one. Draw a figure similar to *fig* 92 *of Glasebrook's Heat*

2 Here 'project' is evidently a misprint for 'produce'

Describe a spectroscope first, that it has got a collimator with a narrow adjustable slit at one end, an observing telescope and a prism placed on a prism table in the centre of a disc which is graduated in degrees and parts thereof

Then give a diagram like fig 131 *Glasebrook's Light* with the description of what takes place, *ibid Art* 112

The dark lines in the solar spectrum are due to the fact that some of the rays proceeding from the very hot necleus of the sun are absorbed as they pass through the outer atmosphere of the sun. An element present in the necleus of the sun may also be present in the solar atmosphere but that always at a lower temperature. In such a case the element at a lower temperature can absorb the rays which it would emit at a higher temperature. Hence the absorption of some of the rays occurs here. The light as it emerges from the solar atmosphere though apparently white, is poorer in those rays which have been absorbed. Such light when analysed by means of a spectroscope reveals some dark lines in places of the spectrum corresponding to those which wonld have been occupied by the absorbed rays. The lines are not absolutely dark but appear to be so in contrast with the contiguous rays which have not been thus absorbed

3 *Focal length of a mirror*,—When *parallel* rays, coming in in a direction *parallel to the principal axis* fall on a spherical mirror, the rays *after reflection converge to or appear to diverge from* a point on the principal axis of the mirror, that point is called the Principal Focus of the mirror. The distance of this point from the *Pole* of the mirror is called the focal length of the mirror

The mirror in question is *concave* for the image produced by it is real as it is formed on the same side as the object

For a concave mirror the object distance 'u', the image distance v, and the focal length f are conndcted by the relation

$$\frac{1}{v}+\frac{1}{u}=+\frac{1}{f}$$

Here $\quad \frac{1}{30}+\frac{1}{10}=\frac{4}{30}=\frac{1}{f}$

Whence $\quad f = 7{\cdot}5\ cm$

escope consists of

wo lenses on the same axis, the objective is always of larger focal length than the Eye-piece the eye-piece nvex lens as in the Astronomical telescope or a concave Galilean telescope. For the diagram to show magnifica- 111 *Glazebrook, Light*

1 erect image by means of a telescope when the eye- oncave one, and an inverted image when it is a

ort a magnet in a paper-stirrup suspended by a resent to it a neutral piece of iron held in the hand is attracted Reverse the arrangement, now the iron (See *De and Roy's Magnetism and Electricity, art*, 5)

experiments to illustrate magnetic induction Do not on the nature of induced polarities (See *De and* *'ism and Electricity, Art 16*)

potential of a conductor is its electrical state which e flow of electricity into or out of it when put in con- a second body For explanation see *De and Roy's* *c art*, 60

nductors are put in connection with each other, they same petential V Now as the total charge on a body e product of its capacity and the potential, we have

$$Q = 10V$$

$$Q' = 15V$$

$$25V = Q + Q' = 1000$$

$$\therefore V = 40 \text{ units of potential}$$

$$Q = 400 \text{ units of charge}$$

$$Q' = 600 \quad ,, \quad ,,$$

ffect on leaves The potential of the earthed cylinder e and any point or body inside it will be at the zero n an electrified body is brought near to the cylinder, of the leaves and the tin-foils at the side of the electro- l zero There being no P. D between the leaves and here will be no divergence

se the electrified body carries a + ve charge As it is the cylinder, induction takes place The induced ge escapes to the earth while the induced -ve charge ne outer surface of the cylinder The electroscope ectrically screened

8 The strength of a current in a circuit is proportional to the electromotive force Thus

$$C \propto E$$

Or $$C = kE$$

Where k is a constant, the inverse of which is called the resistance of the circuit

Hence $$C = \frac{E}{R}$$

i e, the current is directly proportional to the E M F and inversely proportional to the resistance in the circuit.

$$C = \frac{nE}{nr+R} = \frac{2 \times 1\ 5}{2 \times 2 + 6} = \frac{3}{10} = 0\ 3 \textit{ amperes}$$

9 A simple Galvanometer—Describe a tangent Galvanometer The essential parts are a vertical coil of insulated wire and a short magnetic needle suspended or supported at its centre The coil is placed in the magnetic meridian and then the current is passed Circular lines of magnetic force are generated which and to displace the needle in a direction at right angles to the magnetic meridian The needle is displaced and makes an angle with the magnetic meridian, the tangent of the angle may be proved to vary with the strength of the current so that $C = k \tan \theta$ In this displaced position of the needle the moment of the couple due to the earth's horizontal magnetic field is obviously equal to that of the force generated by the current

Telephone—for its construction and action see *Poyser,—Mag and Elecy, p 313*

10 Describe a water voltameter used in electrolysis of water See *Poyser, Mag and Elecy, p 265, fig 233*

The points not to be omitted are—

(*a*) Water must be acidulated with a little sulphuric acid to make it a good conductor

(*b*) Oxygen is collected over the anode

(*c*) A diagram must be given.

(*d*) The vol of H is approximately double of that of O evolved.

The most important difference sought may be given as follows —

In metals when current passes more heat is evolved than that evolved in the case of passage of the same current through liquids

Further in solutions decomposition takes place as the current passes through them, in metals no such thing happens

INDEX.

' . 'lowing to the Main Index given in pp.
.. er the respective heads shown

1921

FIRST PAPER

Candidates are required to give their answers in their own words as far as practicable.

Only SIX *questions are to be attempted.*
The questions carry equal marks.

1 State the laws of Simple pendulum.

How will you proceed to determine the 'g' of a place with a pendulum? Give the practical directions necessary and state reasons. — Pendulum

What is the effect of the height above, or the depth below, the surface of the earth, on the periodic time of a pendulum? Explain

2. Define Specific Gravity of a body

Describe in detail how the specific gravity of a block of alum can be actually determined. — Sp Gr. of a soluble body

3. Describe any form of barometer you have used in your laboratory. Give the directions necessary for reading the atmospheric pressure. — Barometer

4. State Boyle's Law Describe an experiment you would perform for verifying the law. — Boyle's Law.

5 Describe any method for determining the coefficient of linear expansion of a solid — Determination of α

6 How would you proceed to find the specific heat of a liquid? — Sp Ht. of a liquid.

In order to determine the temperature of a furnace, a platinum ball weighing 80 grammes is introduced into it. When it has acquired the temperature of the furnace, it is transferred

quickly to a vessel of water at 15° C. The temperature rises to 20° C If the weight of water, together with the water-equivalent of the calorimeter, be 400 grammes, what was the temperature of the furnace? (Specific heat of platinum = 0 0365)

Vapour-pressure

7 Water can be made to boil at all temperatures. Indicate the conditions that are necessary for the purpose,

What is meant by maximum pressure of water vapour?

S H M.

8 Define Simple Harmonic Motion, and explain it with reference to any familiar example

Siren

9 Describe a siren, giving diagram, and explain how you would use it to determine the frequency of a given tuning-fork

Character of music

10. Distinguish between pitch and loudness What characteristics of vibration determine the pitch and loudness of a musical note?

SECOND PAPER,—1921

Total Reflection.

1 What do you understand by total *reflection* of light?

Mirage

Describe and explain, *with the help of a diagram*, the phenomenon of Mirage

Refraction

2. A speck in the interior of piece of plate-glass appears to an observer looking normally into the glass to be 2 mm from the nearer surface. What is its real distance? The index of refraction of glass may be taken as 3/2

Compound Microscope

3 Describe a compound microscope. Expain, by means of a diagram, how the magnification is produced.

4 Explain, with the help of a *diagram*, the arrangement for a direct-vision spectroscope — Direct Vision Spectroscope.

Describe the different classes of spectra, and cite an example of each kind — Spectra

5 Draw diagrams showing the lines of force due to two equal bar magnets, placed in line with opposite poles facing each other Show how the lines of force are affected in each case by placing (*a*) a bar of iron, (*b*) an iron ring, in line with the magnets and midway between them — Mag lines *of force*

6. Describe and explain the *action* of the electrophorus — Electrophorus

How do you explain the production of innumerable sparks on the principle of Conservation of Energy ?

7 Describe what happens when an insulated charged conductor is brought near a gold-leaf electoroscope, and explain it If a plate of ebonite is held between the changed conductor and the electroscope, will there be any change ? If so, explain — Induction

8 What do you mean by a constant cell ? Describe the construction and action of a Daniell cell — Constant Cell

9 What is meant by an astatic system of two needles ? What is its usefulness ? Explain the principle of the astatic galvanometer — Astatic Needles

10 State the laws of Electrolysis, and describe experiments for verifying them — Electrolysis

11. What is an electromagnet ? — Telephone.

Explain the principle of the Telephone

The pressure exerted by water vapour in contact with water, *i e*, by saturated water-vapour at any temperature is the maximum pressure of aqueous vapour at that temperature It depends on the temperature of the vapour and rises as he temperature rises

8 For the definition of a S H M see *art 83 General Physics*

The vibration of a pendulum ball when the amplitude is small, may be cited as an illustration of a S H M For explanation see *art, 85, Gen Physics,*

9 For the description and a diagram of a siren, see *art 60, De s Sound* For the determination of the frequency of a fork proceed as in *para 4 of the same article*

10 For pitch and loudness *see art 53, Sound*

SECOND PAPER

1. When a ray of light is about to pass (*i*) from a denser to a rarer medium such that (*ii*) its angle of incidence is greater than the critical angle for the two media concerned, it does not refract out into the rarer medium, but suffers a total internal reflection within the denser medium

Mirage—A diagram is essential See the *answer to Q 2, Paper II, 1917*

2 Establish the formula $u = \mu v$ by drawing a figure for normal view of an object in a medium denser than air Here,

$$u = \tfrac{3}{2} \times 2 = 3 \text{ mm}$$

3 For the description and diagram of a compound micros-cope—*see Glazebrook, Light, art 101*

4 When a ray of white light is made to pass through a flint glass prism, it is deviated towards the base of the prism, and at the same time it is broken up into its constituent seven primary colours the rays of different colours deviating by different amount from the original direction of the incident ray This is called Dispersion Now if a second prism of a different transparent substance, say crown glass, be placed next to the first with its refracting edge turned away from that of the first, and the refracting angle of this be such that the mean ray say the yellow ray is deviated through the same angle in an opposite direction due to the prism No 2 then it may be proved that the deviations of the other rays due to prism No 2, are opposite in direction, but are not equal to those respectively of the same rays due to the prism No 1 In other words, there is some dispersion still left while the mean path of the emergent light is approximately the same An eye placed in the other side of the prisms will, on seeing straight through the prisms, view a spectrum. A tube-

containing two or more prisms to serve the purpose described above, with a slit on one side and an aperture for the eye on the other forms a Direct Vision Spectroscope (*for fig. see Ganot P. 445*)

For the different classes of spectra see answer to Q. 2—11—1916

5 For a diagram of the field between N and S-seeking poles of two equal bar magnets, see *fig 44 De's Mag and Elec*

If a bar of iron be placed in between the poles the lines of force tend to pass through the iron Hence there will be crowding of lines in the spaces between each pole and either end of the bar. It is to be noted that the lines which enter the bar by one end, pass through the length of the bar and are out by the other edge; thus they are closed continuous lines Draw a figure

Similar is the case when an iron ring is placed between the poles, *See p 53 Mag & Elec*

6 For electrophorus see *art 9, De's Mag and Elec* For the source of the spark energy *read para 1 p* 175

7 When an insulated charged conductor is brought near a gold leaf electroscope, the charge on the conductor induces a a charge of the opposite kind in the disc and a charge of the same kind on the leaves of the electroscope these two induced charges being equal Hence the leaves diverge

When an ebonite plate is interposed between the charged conductor and the disc of the electroscope, more lines of force pass through this ebonite, as the specific inductive capacity of ebonite is greater that air The result is that induction is now greater, hence the divergence of the leaves will increase

8 A constant cell has a constant E M F due to the prevention of polarisation in it Hence in any circuit such a cell will send out a constant current

For the diagram and description of and action in a Daniell cell *See art 114, De's Mag and Electricity*

9 For the meaning of an astatic system—*See para 8 p 242 De's Mag and Elec* For its usefulness se *para 3 p 242*

For the principle of Astatic Galvanometer, read *para 2 p 243 De's Mag and Elec* Note that a discription of astatic galvanometer is not here asked

10 For the laws of electrolysie see *art 161, De's Mag & Elec* Conclude by citing the formula $W=ZCt$

Experiments —(1) The same current C passing through copper sulphate and silver nitrate solutions in the proportion of their chemical equivalents

(2) Double the current, the deposit in each electrolytic cell will be doubled

(3) Double the time again, the deposit will be doubled

11 For the meaning of an electromagnet see *art*, 130, *De's Mag* and *Electricty*

For the description of a Telephone see *art.* 193 *De's Mag & Elec*

INDEX.

Please add the following to the Main Index given in pp 215 (*i*) —215 (*v*) *under the respective heads shown* —

1922.

FIRST PAPER

Candidates are required to give their answers in their own words as far as practicable

Only SIX *questions are to be attempted*

The questions carry equal marks.

1. Explain clearly what you understand by Work and Energy State the principle of Conservation of Energy and illustrate it with two examples. Work and Energy

If the clouds were three-fourths of a mile above the earth and rain enough fell to cover half a square mile of the surface half an inch deep, how much work was done in raising the water to the clouds? From what did the energy come?

2 Describe with a sketch the balance you have used in your Laboratory. What are the requisites of a good balance? Balance

3 State Pascal's law as to the transmission of pressure in a liquid. Pascal's Law

Describe the principle and action of a Hydraulic Press, giving a sectional diagram.

4. State what happens in the following cases, giving reasons:

(*a*) A glass tube 20 inches long, closed at one end and entirely filled with mercury, is inverted over a mercury trough. Atmos. pressure

(*b*) A narrow glass tube open at both ends is partially dipped in a vessel containing water. The upper end is closed by the thumb and the tube taken out of water.

xpansion of liquid

5 What is meant by the coefficient of cubical expansion? Distinguish between real and apparent expansion of liquids.

A piece of glass weighs 47 grammes in air, 31 53 grammes in water at 4°C, and 31·75 grammes in water at 60°C. Find the mean coefficient of cubical expansion of water between 4°C and 60°C., taking that of glass as 000024

Lt ht of fusion

6 Explain clearly what you mean by the latent heat of fusion.

Find the latent heat of fusion of melting ice from the following data:

Weight of calorimeter —60 grm

Weight of calorimeter + weight of water —460 grm.

Initial temperature of water —38° C

Temperature of the mixture —5° C

Weight of calorimeter + weight of water + weight of ice —618 grm.

Specific heat of the substance of the calorimeter —0.1

Change of State

7. Describe the changes that take place when heat is applied to a mass of ice at −10°C. till it is converted into steam at 100° C

Vapour pressure

8 What is meant by the maximum pressure of water vapour? Describe an experiment to determine it from the laboratory temperature to 100° C.

Prop and Vel of sound

9 Explain clearly how sound is propagated in air Describe a method how velocity of sound in air may be determined experimentally.

Vibration of springs.

10 State the laws of the vibrating strings.

A copper wire (density 8 8 grammes per c c) 100 cm long and 1 8 mm. in diameter

is stretched by a weight of 20 kilos. Calculate the pitch of its fundamental note

SECOND PAPER.

1. What is meant by the *image* of an object? Distinguish between real and virtual images. Image

Explain and illustrate by a sketch the formation of each kind in a concave mirror. Explain why only virtual images are formed in convex mirrors Spherical Mirrors.

2. What is total internal reflection and in what circumstances does it occur? Bubbles of air coming out through water in a glass vessel appear silvery to an observer standing by the side Explain this Total reflection

3 How would you produce a pure spectrum on a screen? Sketch and describe the apparatus you would use. Spectrum

Account for the presence of the dark lines in the solar spectrum.

4 You are given two convex lenses of focal lengths 60 cm and 3 cm respectively. How do you arrange them to form— Microscope and Telescope

(*a*) a compound Microscope.
(*b*) a Telescope

Draw diagrams and explain the arrangement.

5 Explain what is meant by the pole of a magnet and a line of force in a magnetic field. Describe how you would proceed to determine the position of the poles of a bar magnet Pole of a magnet

6 An insulated charge is brought near a gold-leaf electroscope Draw a diagram showing the lines of force and from it explain the movement of the gold leaves. Elec lines of force

Ice-pail experiment

7. The quantity of electricity produced in induction is equal to that on the inducing body. How will you prove the statement by an experiment?

Tangent Galvanometer

8 Describe and explain the action of a Tangent Galvanometer.

Ruhmkorff's coil

9. Give a sectional diagram of Ruhmkorff's coil, with an index of parts, and explain its action.

Barlow's wheel

10 A toothed wheel is capable of rotation about a horizontal axis perpendicular to its plane Describe in detail an electromagnetic arrangement for producing continuous rotation of the wheel. Specify the direction of rotation corresponding to the particular arrangements you propose.

ANSWERS

N B —*Denominations in answers should never be omitted* further, care must be taken that they are *not mis stated*

FIRST PAPER

1 Work— see De's General Physics Art 90
Energy— Ditto Art 92
Principle of conservation of energy — Ditto Art 97
In each case give at least one illustration

In the example given,—

$$\text{Vol of water of rain-fall} = \tfrac{1}{2} \text{ sq mile} \times \tfrac{1}{2} \text{ in}$$
$$= \tfrac{1}{2} \times 1760^2 \times 3^2 \times \tfrac{1}{2 \times 12} \text{ cuft}$$

But 1 cu ft of water weighs 62·5 lbs.

mass of water of rain-fall

$$= \tfrac{1}{2} \times 1760^2 \times 9 \times \tfrac{1}{2} \times \tfrac{1}{3 \times 12} \times 62{\cdot}5 \text{ lbs}$$
$$= 330 \times 1760 \times 62{\cdot}5 \text{ lb}$$

This has been raised through 3/4 of a mile above the ground

$$\therefore \text{work done} = 330 \times 1760 \times 62{\cdot}5 \times \tfrac{3}{4} \times 1760 \times 3 \text{ ft lbs}$$
$$= 143748 \times 10^6 \text{ ft lbs}$$

Source of energy—is the heat of the solar radiation.

2 For a description and sketch of the balance
—see *De's Physics, Art* 11.
For the requisites of a good balance —Ibid, art 81.

3 For the statement of Pascal's law —*ibid, art* 130
For description with diagram and the explanation of action of a Hydraulic Press *ibid art.* 131—2.

4 (*a*) As the length of the glass tube is less than 30 in, which is the average height of mercury column in a barometer, mercury in the inverted tube will not fall

(*b*) While the tube is being taken out, some drops will come out as the air enclosed above the water-level has the same pressure as that of the outside air But as the water drops out, air has to expand and thereby falls in density hence its pressure becomes less When the reduced pressure of air inside *plus* the pressure of water at the open end of the tube become equal to the atmospheric pressure, water will not come out any more.

5 Coefficient of Cubical expansion—see *Glazebrooke's Heat, art 62*

Distinction between real and apparent expansion of liquids—*ibid. art* 76

For the example given —

Loss in wt. of glass piece $=47-31\ 53$ grams
$=15\ 47$ grms
$=$wt. of displaced water at 4°C

Vol of displaced water $=15\cdot47$ cc
$=$vol of glass piece at 4°C

Vol of glass at 60°C $= 15\ 47\ \{1+\cdot000024(60-4)\}$ c c.
$= 15\ 47(1+000024\times56)$ c c
$= 15\ 47\times1\ 001344$ c c
$= 15\ 491$ c c

This will be also the vol of water displaced at 60°C

Wt of water displaced of 60°C
$=$ vol $\times$ density
$= 15\ 491\ (1-56\gamma)$ for $\rho t=\rho o\ (1-\gamma t$
$= 15\ 491-867\ 5\ \gamma$ gms

This is also given by $47-31\ 75$ gms or $15\ 25$ gm s.

Hence $\gamma = \dfrac{15\ 491-15\ 25}{867\ 5} = 00028$

6 For Lt ht of fusion—See *Gl Heat Art 41*

For the example given—

Heat lost by cal and its contents $=$ Heat gained by ice

$(60\times0\ 1+400)\ (38^\circ-5^\circ)=158\ L+158\ (5^\circ-0^\circ)$

whence $L = 79\ 8$ heat-units

7 From—-10°C to 0°C— vol of ice expands and its temp rises

At 0°C —heat supplied melts the ice Volume decreases

From 0°C to 4°C —volume of water decreases up to 4°C hence maximum density of water at 4°C

From 4° to 100°C —water expands.

At 100°C —water boils and steam is being rapidly formed, vol expands about 1700 times

8 When a space is saturated with water vapour at any temperature t, the pressure exerted by the vapour is then maximum and is called the saturation pressure of aqueous vapour at t°C.

For an experiment to determine the pressure of saturated vapour from the laboratory temperature up to 100°C. proceed as in *expt 36, Gl. Heat, P. 137.*

9 For mechanism of propagation of sound in air—see *De's Sound art. 7.*

For experimental determination of vel of sound in air—ibid, art 76.

10 Laws of vibrating strings—see *De's Sound, Art. 66.*
For the example given,—

$$n = \frac{1}{2l}\sqrt{\frac{T}{m}} \qquad [\text{ De's Sound, Art 67.}$$

$$= \frac{1}{2 \times 100}\left(\frac{20 \times 1000 \times 981}{m}\right)^{\frac{1}{2}}$$

where m = mass per unit length
$= \pi r^2 \times 1 \times \rho$
$= 22/7 \times (.09)^2 \times 8{\cdot}8$ gm.
On clearing n = 47.

SECOND PAPER

1 *Image*—Rays proceeding from any point of the object after reflection or refraction, do actually converge to or appear to diverge from a second point This latter point is the image of the first point. In the former case, the image is real in , the latter, it is virtual The real image can be received on a screen while the virtual one can not be so received but is simply seen by the eye

For the formation of a *real* image by a concave mirror see *Glazebrook's Light* fig 66 , for that of a virtual Image by the same *ibid* fig. 69.

A convex mirror has its centre of curvature and principal focus both behind it *i.e.*, on the negative side. Hence all rays

incident on it do, after reflection, diverge so that they never intersect in front To an eye receiving the reflected rays the image seems to be formed behind the mirror, *i e* the image is virtual, for figure see *Gl Light* fig. 71

2 *Total Internal Reflection*—When rays pass from an optically denser medium to a rarer one, they are bent away from the normal As the angle of incidence increases, a limit comes when the corresponding angle of refraction becomes 90° *i e*, the refracted ray just grazes the surface of seperation This value of the angle of incidence is called the *Critical Angle* If the angle of incidence increases still furthur, there is no refracted ray, the ray is then reflected totally at the point of incidence into the same medium, and is necessarily much brighter than an ordinarily reflected ray Hence the conditions of total reflection are —

(1) The ray is to pass from a denser to a rarer medium

(2) The angle of incidence must be greater than the critical angle for the two media

When rays pass through water and fall on the surface of air bubbles, some of them may be oblique enough, so that the corresponding angles of incidence exceed the critical angle for water and air These latter will then suffer total reflection at the surface of air bubbles and give a bright silvery appearance to the air bubbles to an observer standing at the opposite side-

3 For the production of a pure spectrum on a screen the following things are necessary —

(*a*) A narrow slit, *S*, through which white light is to pass

(*b*) a convex lens, *L*, placed at a distance $2f$ from *S* this will coverge the pencil diverging from *S*, to a narrow image *S'* on the otherside at a distance $2f$ from it

(*c*) a *Prism* to disperse each ray into its constituent rays The prism, when placed in the mininunm deviation position, reduces the spread of each colour to a minimum

(*d*) a screen, *G*, to receive the spectrum, its position being at a distance $2f$ from the lens *L*

For a sketch see *Gl Light*, fig 129

The dark lines in the solar spectrum are due to absorption of some of the solar rays in the solar atmosphere Rays proceeding from the very hot nucleus of the sun have to pass though its outer sphere consisting of some of the elements present in the nucleus in the vaporous condition at a less high temperature But Dr Kirchhoff has experimentally shown that vapour can absorb the very rays which they emit at a high temperature, when light having a higher temperature is made to pass though such vapours Hence absorption takes place in the solar atmosphere. Thus the white

light travelling out in space is deficient in some of its constituent rays, the fact being revealed by the occurrence of dark lines when the light is analysed by means a spectrometer It is quite true that the vapours will, on the otherhand, emit their own rays, but these being of much less intensity appear dark in the spectrum by contrast with those rays which are not absorbed

4. In both the instruments the convex lenses are to be fitted in a tube *co-axially.* The eye piece is generally fitted into a tube which slides into the tube containing the objective

(*a*) *A Compound Microscope*—Here the objective is lens of a smaller focal length (*viz*, 3 cms here), while the other lens of 60 cms focal length forms the eye-piece A small object, PQ, is placed just beyond the principal focus of the objective which produces a magnified, real and inverted image pq of the object of a distance. The eyepiece is adjusted to have pq within its own focal length so as to throw a virtual and a furthur magnified image $p'q'$ of PQ at the distance of distinct vision The final image $p'q'$ is inverted with reference to the object PQ.

N B.—The question is theoretically all right But an eye piece of 60 cm focal lengh in a microscope is an unusual thing not to be realized in practice !

(*b*) *A Telescope*—The arrangement of the lenses is just the opposite of that adopted in Microscopes. Here the objective is of longer focal length Rays proceeding from any point on the distant object travel as a parallel pencil and are brought to focus in the focal plane of the objective The image pq, thus formed, is real, inverted and smaller in size than the object The position and action of the eye-piece are similar to those in the microscope.

N B —In the diagram wanted, the passage of rays need not be shown

5 *Pole* of a magnet.—The regions near the two ends of a magnet where the attraction is most powerful, are termed its poles —*De's Magnetism, Art* 3

A Magnetic line of force — see *De's Mag Art* 33

To determine the position of the poles of a bar magnet.—*See De's Prac. Physics, P* 206

6 Lines of force will pass from the charged body (supposing this, to be positively charged) to the disc of the electroscope, and will be out again, passing from the gold leaves to the tin-foils at the sides of the electroscope [see *De's Electricity, fig* 90 (*a*)

As the lines of force are supposed to have been under a tension length-wise, leaves are brought towards the tin-foils on either side, whereby there is a divergence produced between them

7 It is Faraday's Ice-pail experiment See *De's Elec Expts 62 and 63*

8 For a description and action of a Tangent galvanometer see *De's Elec, art 136*

9 For a description and action of Ruhmkorff's coil see *De's Elec fig 263, P 440*

10 This is Barlow's wheel arrangement For figure see *De's Elec, art 175* The rotation can be explained either from

(1) the nature of the combined magnetic field due to the magnet and the current (*Ibid fig 241*) *or*

(2) by means of the Amperian current supposed to be flowing round the magnet (*Ibid fig 243*)

INDEX.

Please add the following to the Main Index given in pp 215 (*i*) —215 (*v*) *under the respective heads shown* —

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